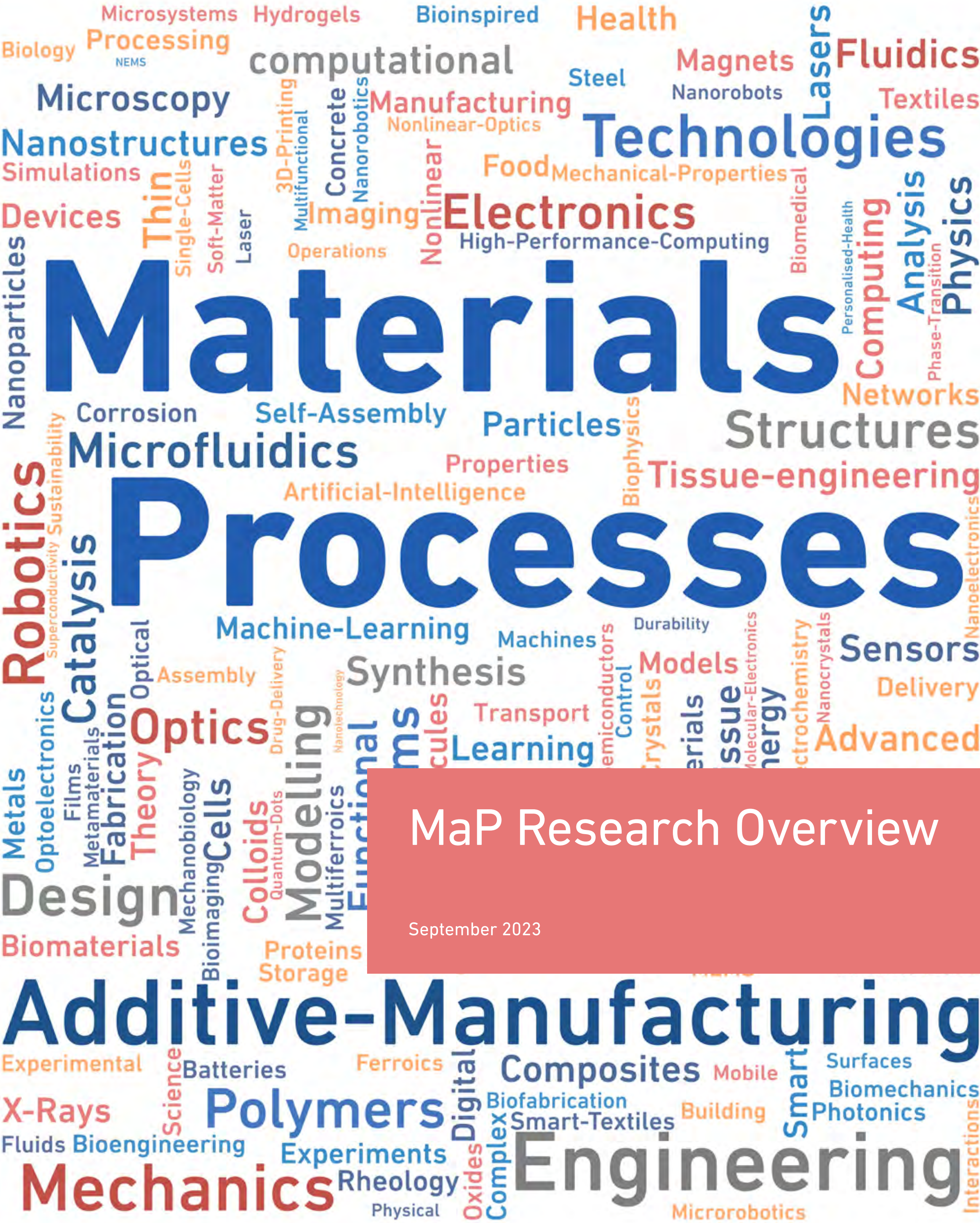
ETH zürich

MaP | Competence Center for Materials and Processes

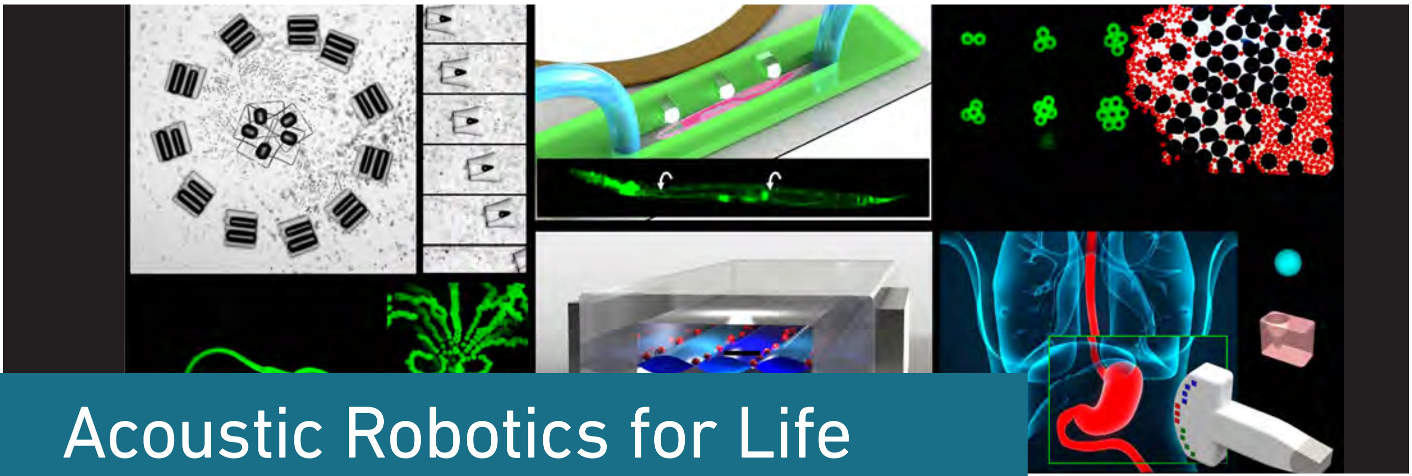


MaP Research Overview

September 2023

MaP Competence Center for Materials and Processes

Content



Acoustic Robotics for Life Sciences and Healthcare

Research Profile

The Acoustic Robotics for Life Sciences and Healthcare Lab (formerly Acoustic Robotics Systems, ARSL), located in the Binnig and Rohrer Nanotechnology Center, is engaged in developing innovative acoustic-based technologies for applications in biomedical engineering, diagnostics, and translational medicine. High-frequency acoustic fields at moderate levels of pressure is regarded as a safe, non-invasive, and relatively inexpensive procedure, and is used extensively in clinical diagnostics and therapeutics. The lab focuses on

- novel micro- and nanosystems for life sciences and biology
- micro- and nanorobots for in vivo navigation in small animal models
- investigation of disease models in microfluidics and animal models
- translation of the new technologies into healthcare applications
- ultrasound-assisted additive manufacturing

Competences / Infrastructure

- Acoustic-based micro- & nanorobots
- In vivo acoustic manipulation systems
- Ultrasound & high-speed imaging capabilities
- Fabrication of micro- & nanodevices
- Robot-assisted lab-on-a-chip systems
- Acoustic-based 3D printing

ETH Zürich
Department of Mechanical and Process Engineering
Acoustic Robotics for Life Sciences and Healthcare

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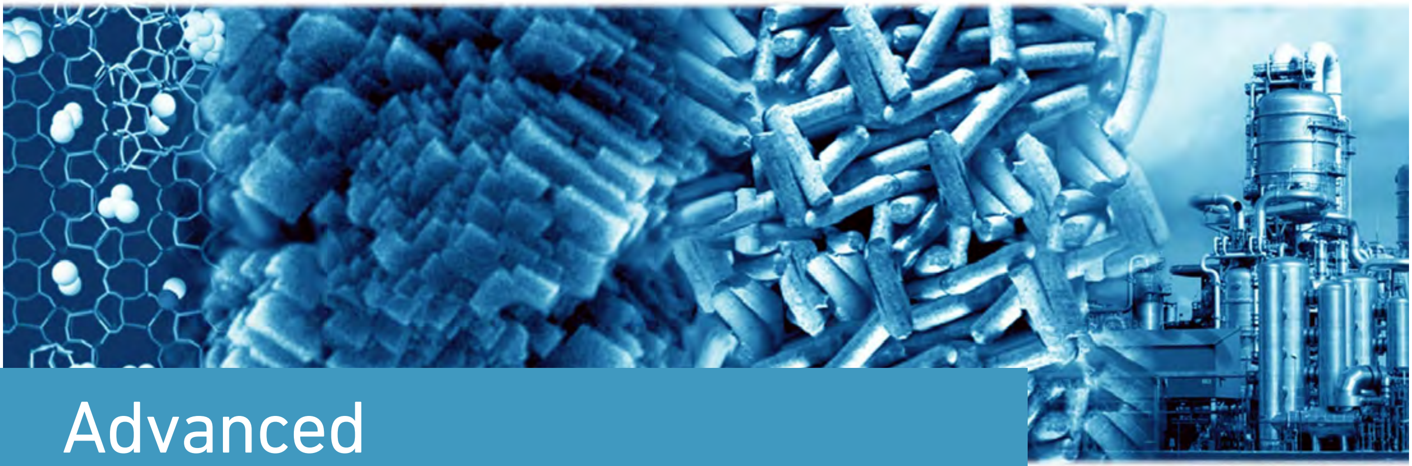
The Acoustic Robotics for Life Sciences and Healthcare Lab (formely Acoustic Robotics Systems Lab) is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

additive manufacturing | bioinspired acoustics | transformative microrobots acoustic 3D printing | micro- & nanorobots



Advanced Catalysis Engineering

Research Profile

The Advanced Catalysis Engineering (aCe) Group is engaged in the design of heterogeneous catalysts and reactor engineering concepts devoted to sustainable technologies. To tackle current and future energy, resource, and environmental challenges of society, we develop ground-breaking closed-loop manufacturing routes to key platform chemicals from abundant and preferably renewable feedstocks. Our research combines creative discovery with deep structural and mechanistic understanding, to guide the engineering of optimally nanostructured catalysts, but also emphasizes the bridge between molecular level and application in technical scale. This multidimensional task requires expertise at the broad interfaces of materials science, chemistry, and chemical engineering. Following this approach, aCe has pioneered catalysts that enable selective paths for CO_2 hydrogenation to methanol and halogen-mediated functionalization of natural gas components, as well as for conversion of renewables to chemical building blocks. We have also advanced techniques for applying noble metals in the form of defined ensembles or single atoms as well as for analysing pore quality in hierarchically-organized materials. Continued emphasis is placed on strengthening the implementation of operando methods and high-throughput experimentation to accelerate these activities.

Competences / Infrastructure

- Gas-to-value
- Chemo- and electrocatalytic CO_2 conversion
- Valorisation of renewables and waste
- Selective hydrogenations
- Single-atom catalysis
- Hierarchically-organized materials
- Interfacial effects
- Adsorption and diffusion studies
- Surface functionality assessment
- Catalyst scale up

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The Advanced Catalysis Engineering Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

reactor engineering | environment | energy
sustainable technologies | catalyst design

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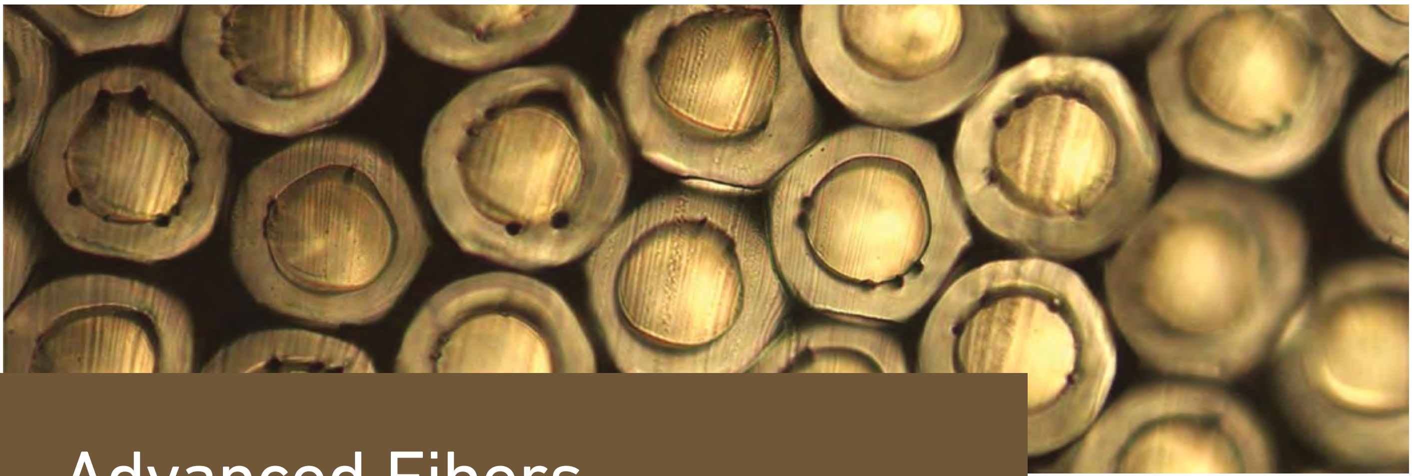

Advanced Fibers

Research Profile

Fibers represent a high-performance material form, which offers direct pathways to industrial transfer. A synthetic fiber is much more than a simple polymer thread; the performance-determining factor of a fiber lies within its molecular structure. Small crystals tie together with oriented polymer molecules; the interplay between these domains directly determines the fiber flexibility and tensile strength. We modify the fiber structure at different scales using novel multi-component fiber spinning processes. Mastering the interplay of materials science and processing is key.

Profound understanding of chemical bond making and breaking is required to modify polymers and synthesize polymer additives. We focus on sustainable synthesis routes as well as the understanding of how molecules disintegrate at the end of the material lifetime.

Many relevant fiber properties are determined at its surface and are particularly significant for interfacing with aqueous or humid environments. We have the means to study such interactions in detail and derive innovative strategies to modify the specific surface properties. Many of our fundamental research projects are directed towards a later industrial transfer; we are thus in contact with industries covering a wide range of materials forms including wood, foams, foils, fibers or textiles.

Competences / Infrastructure

- Polymer fiber physics
- Polymer melt-processing (pilot plant)
- Polymer & Additive Chemistry (synthesis lab)
- Surfaces & Interfaces (surface analytics)
- Plasma Physics & Chemistry (pilot reactors)

ETH Zürich | Department of Materials
Empa | Functional Materials Department
Advanced Fibers

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fibers | surfaces | interfaces
melt processing | synthetic chemistry
polymers | plasma technology

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Advanced Manufacturing

Research Profile

"Reinventing manufacturing" is the motto of the Advanced Manufacturing Laboratory (aml), which develops new manufacturing technologies to overcome the limitations of current manufacturing processes. The labs major goal is "Scale Invariant Manufacturing" aiming at developing technologies that allow the unit production costs to be independent of quantity, manufacturing variants or component functions. Additionally, manufacturing technologies will be developed to precisely control component properties at any point. Driven by global challenges, such as scarcity of resources and climate change, these manufacturing technologies will be developed to be sustainable e.g.: by increasing control over component properties, the production of faulty parts and industrial waste can be avoided. To achieve the goals named above, the lab investigates the influence of processes on materials and develops production machines to support novel manufacturing technologies with regard to challenges like digitization, robotics, artificial intelligence (AI) or biologization. The lab focuses in particular on the processing of metallic materials and multi-material compounds, including processes along the entire value chain with a specific focus on additive as well as hybrid manufacturing processes and advanced process control.

Competences / Infrastructure

- Laser metal deposition
- Wire-arc additive manufacturing
- Metallic materials & atomization
- Multi-material compounds
- Modelling and simulation
- Digitisation & AI
- Production engineering

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reinvention | scale invariant manufacturing
process control | property control
sustainability | additive manufacturing

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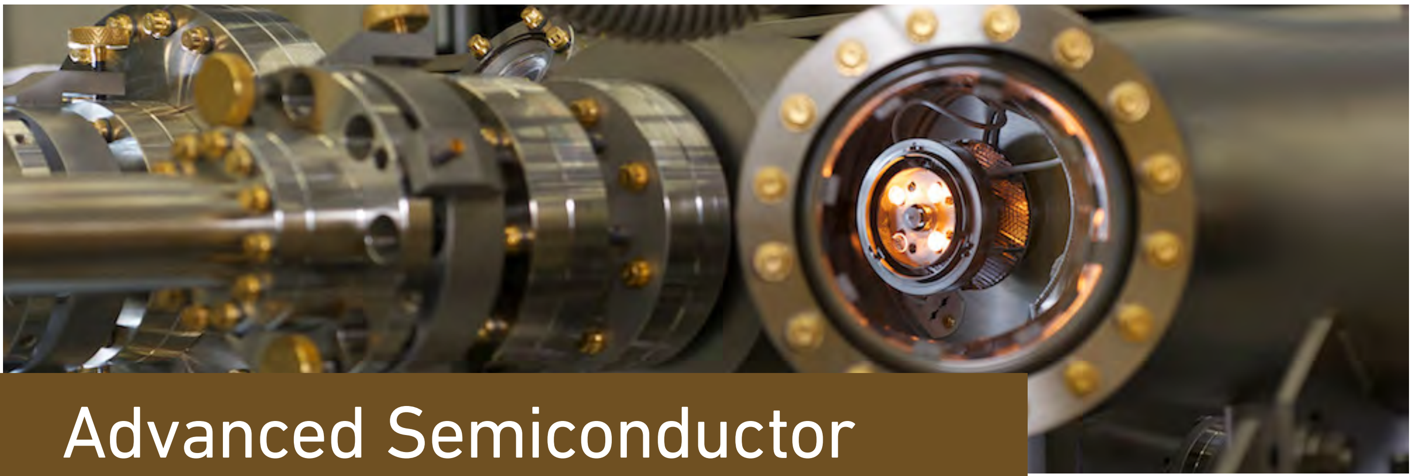

Advanced Semiconductor Quantum Materials

Research Profile

Sophisticated molecular beam epitaxy (MBE) techniques are the most powerful tools for the fabrication of highest-purity III/V-semiconductor heterostructures. Besides fabrication, the group is interested in characterizing optical and electronic properties of these structures. One of the group's main aims is to study novel quantum phases in systems of reduced dimensionality. In the GaAs/AlGaAs material system, these form at very low temperatures when the sample containing a two-dimensional electron system (2DES) of ultrahigh mobility is exposed to a strong magnetic field and (fractional) quantum Hall effect phases form.

Furthermore, InAs/Al(Ga)Sb-based systems are fabricated and investigated. For these structures with broken band alignment, a tunable topological insulator is predicted. In addition, the group supplies highest-quality and tailored 2DESs for a large number of experimental groups in-house as well as at other universities and in industry worldwide.
In order to determine the spin state and local properties of highest-mobility electron systems, standard magneto-transport measurements are combined with optical spectroscopy and nuclear magnetic resonance (NMR) to understand the nature of the many-body ground states of these systems.

Competences / Infrastructure

- Molecular beam epitaxy (MBE) systems for ultrahigh-mobility samples based on Arsenides and Antimonides
- Low-temperature magnetotransport and -optics cryostats reaching temperatures of 20 mK and field strengths as high a 16 Tesla
- Photoluminescence and Raman setups

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The Advanced Semiconductor Quantum Materials Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

electron transport | molecular beam epitaxy
semiconductor heterostructures | thin films
quantum dots | optics | quantum hall fluids

Air Quality and Particle Technology

Research Profile

The Air Quality and Particle Technology Group conducts research in the fields of measurement of airborne pollutants, assessment of health and environmental impacts, and emission control and abatement. One of the group's major aims is to remediate environmental and health threats posed by emerging airborne pollutants using cutting-edge technologies. For this reason, precision engineering of air pollution control systems is performed. These systems are characterized by the synthesis of separation and filtration media with nanometer-scale tunable structures, ultra-sensitive detection of pollutants, and highly automated active removal mechanisms with precise selectivity. The combination of these characteristics enable the requested control efficiency without wasting energy or materials. In addition the group is also involved in (i) understanding health and environmental impacts of nanomaterials and nano-enabled-products by measuring their release into the environment and toxicity, (ii) fabrication of affordable, accurate, and reliable microsensors for localized real-time measurements of pollutants, and (iii) emission measurement for various sources and works on global emission inventories and air quality modelling.

Competences / Infrastructure

- Airborne particle measurement by electrical and optical methods
- Emission monitoring and air quality modelling
- Health and environmental impact of airborne pollutants
- Control technologies including filtration and catalysis
- Bioaerosol analysis
- Functional materials for pollutant sensors
- 3D printer for micro/nano-structures

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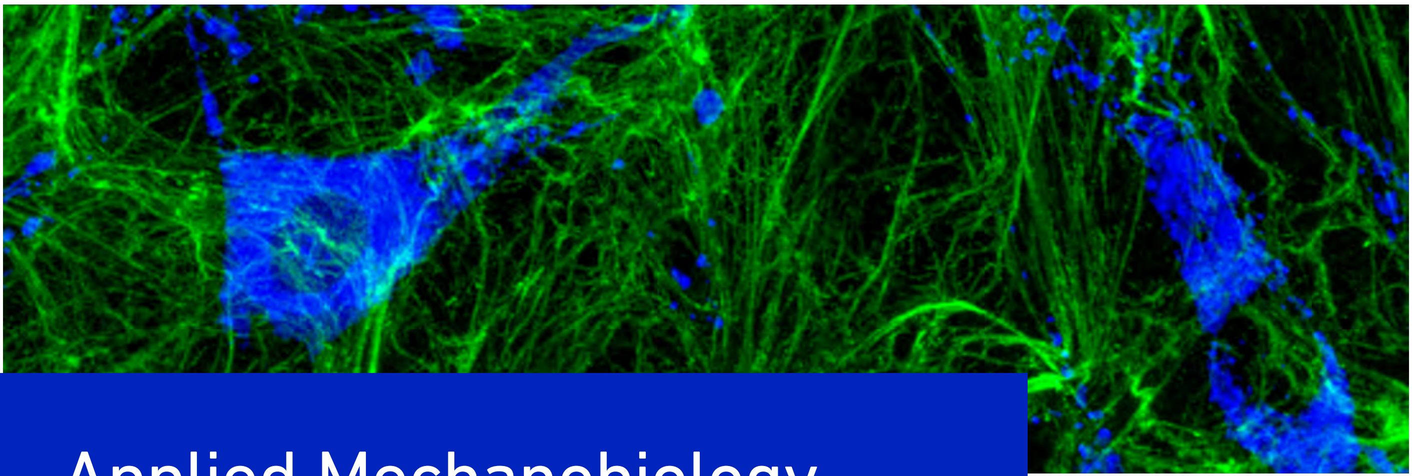
The Air Quality and Particle Technology Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

sensors | flexible 3D electrodes | aerosols
additive manufacturing | health impact
air quality | emission control | filtration



Applied Mechanobiology

Research Profile

The Applied Mechanobiology Laboratory exploits nanotechnology tools to decipher how bacteria, mammalian cells, and micro-tissues take advantage of mechanical forces to recognize and respond to material properties in their native environments. Our overarching goal is to discover mechanisms how nature exploits mechanical forces as an additional dimension of functional regulation and how these insights can be exploited for biomedical applications and in regenerative medicine. This includes asking how the mechanobiology of extracellular matrix (ECM) directs stem cell differentiation and (micro)tissue growth and functions. Also bacteria sense mechanical forces which regulate their adhesion to surfaces and tissue fibres, and immune cells use mechanical forces to fight bacterial infections. The discoveries of the Lab in single molecule and cell mechanics and how protein stretching switches their function, have a wide range of technical and medical implications. In collaboration with clinicians, several technologies are currently carried towards preclinical studies. Our future goal is to exploit our interdisciplinary strength in basic research, while translating key discoveries towards the clinic.

Competences / Infrastructure

- Micro- & nanofabrication, substrate patterning & functionalization
- Fluorescent resonance energy transfer (FRET) based tension probe of fibronectin
- Traction force microscopy, confocal laser scanning (TIRF, FLIM), fluorescence (epi, confocal microscopy, live-cell), electron (SEM, TEM) microscopy
- Cell culturing facilities (biosafety level 1 & 2 labs)
- Wet lab, biochemical & biophysical equipment
- Molecular biology: PCR, RT-PCR, ELISA, Western Blot, Zymography, DNA/RNA isolation, transcriptome analysis
- Molecular Dynamics (MD) simulations, statistical analysis

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ECM cues | molecular bioengineering | biophysics
nano- and microfabrication | protein mechanics
tissue engineering | cell-pathogen interactions

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Architecture and Digital Fabrication

Research Profile

The Chair of Architecture and Digital Fabrication, also known as Gramazio Kohler Research (GKR) at ETH Zurich, examines the changes in architectural production requirements that result from introducing digital manufacturing techniques. The interest of GKR lies in combining data and material and the resulting implications this has on the architectural design. The possibility of directly fabricating building components described on the computer expands not only the spectrum of possibilities for construction, but, by the direct implementation of material and production logic into the design process, it establishes a unique architectural expression and a new aesthetic.

The research focuses on additive digital fabrication techniques used for building non-standardized architectural components. By positioning material precisely where it is required, we are able to interweave functional and aesthetic qualities into a structure. It is thus possible to "inform" architecture through to the level of material. Starting with modules such as bricks as a basic material, the research has expanded the spectrum to include wood, clay, concrete and other fluid materials.

Competences / Infrastructure

- Architecture and digital fabrication
- Robotic fabrication
- Augmented fabrication
- Computational design
- Bringing research into built projects

- Robotic Fabrication Lab
- Immersive Design Lab

ETH Zurich
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Chair of Architecture and Digital Fabrication
Gramazio Kohler Research

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The Gramazio Kohler Research (GKR) group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

architectural design | robotic fabrication | computational design

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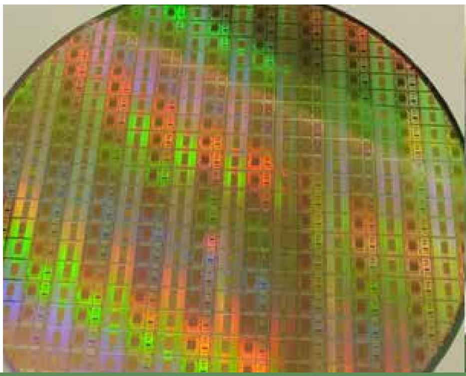
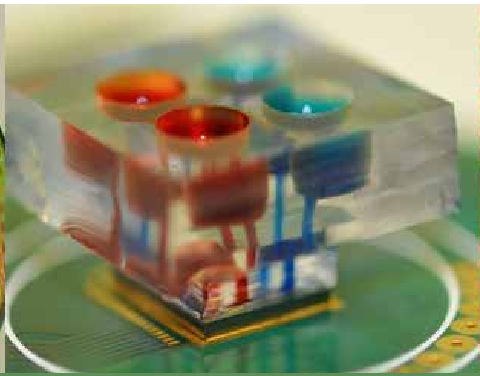
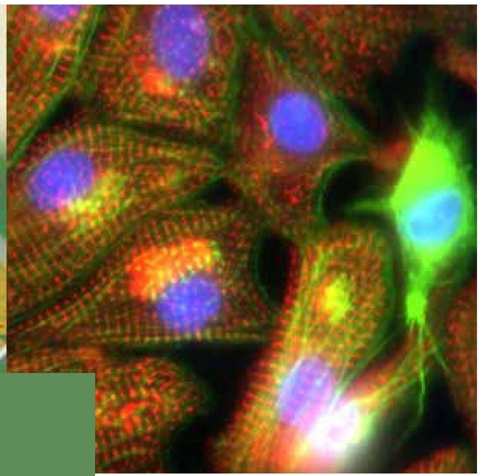

Bio Engineering

Research Profile

The Bio Engineering Laboratory (BEL) is rooted in Engineering and Physics and is engaged in developing and applying micro-technological, microfluidic, and microelectronic technologies to address questions in biology and biomedicine. Our group has longstanding experience in the development of CMOS-technology-based (CMOS: Complementary Metal Oxide Semiconductor), integrated chemical and biomicrosystems, as well as bioelectronics and microelectrode arrays. Moreover, we are engaged in the development of microfluidics for investigating the characteristics of cells, microtissues, and organoids. The three main research directions include:

- Development of integrated bio- and chemo microsystems in CMOS technology.
- Extracellular electrophysiology of electro-active cells, directly interfaced to CMOS high-density microelectrode arrays; research in fundamental neuroscience and pharmacology.
- Development of microfluidic devices for microtissues, organoids, and barrier tissue models with applications in systems biology and compound testing.

Competences / Infrastructure

- Transducer and circuit design (CMOS technology)
- Micromachining and microfluidics (MEMS)
- Microtechnological cleanroom
- Biosensors and bioelectronics
- Cell cultivation and handling
- Microfluidic setups and systems
- Characterization of microtissues, organoids, and barrier models
- Chip-based electrophysiology and neuroscience

ETH Zürich
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Bio Engineering

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microtechnology | microtissues
microfluidics | organoids | neuroscience

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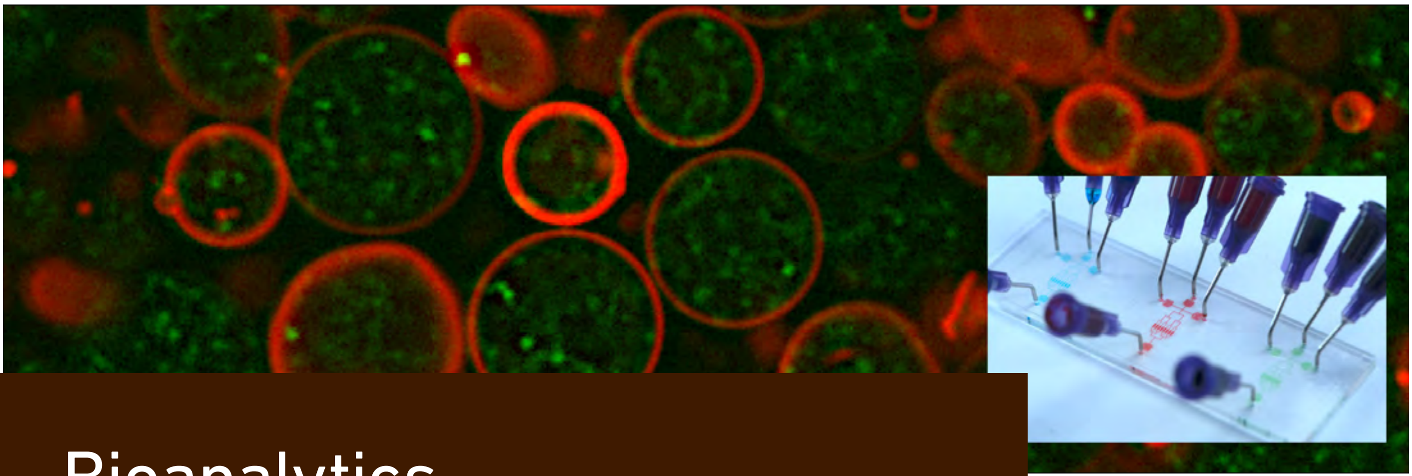

Bioanalytics

Research Profile

We develop miniaturized devices (so-called lab-on-chip technology or microfluidics) for the life sciences, particular for bioanalytical and diagnostic applications. In our interdisciplinary approach chemical, physical, biological and engineering aspects of microfluidic-based technology are combined.

Our current research projects focus on:

- Single-cell analysis, investigation of cellular response to (chemical, physical or mechanical) perturbations; development of novel microfluidic platforms for single cell proteomics and metabolomics
- Microfluidic platforms for cell screening and miniaturized cytometry
- Membrane analysis: Permeation, fusion, lysis, and pore formation in membranes
- Bottom-up engineering of minimal cells

Competences / Infrastructure

- Micro- and nanofabrication, chip design, photolithography, soft lithography, multilayer soft lithography, hot embossing, 3D printing, surface patterning
- Microfluidics, droplet/digital microfluidics, micro-cytometry
- Cell cultivation and handling
- Liposome formation and analysis
- Fluorescence microscopy, confocal laser scanning microscopy, TIRF and FCS
- Mass spectrometry (ESI-MS, MALDI-MS)

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lab-on-chip technology | sensors
minimal cells and liposomes
microfluidics | single-cell analysis

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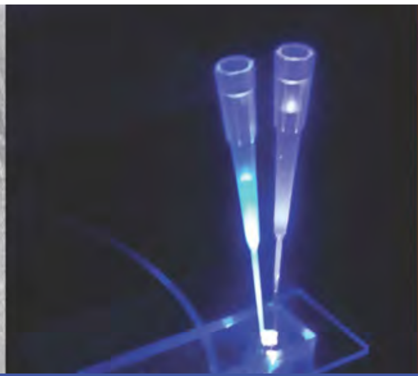


Biochemical Engineering

Research Profile

The Laboratory for Biochemical Engineering conducts interdisciplinary research at the interfaces between chemical engineering, biochemistry and biophysics advancing both experimental characterization and theoretical models in biomolecular physical chemistry to solve concrete problems in biomedical and pharmaceutical biotechnology, with a special emphasis on protein self-assembly:

- Amyloid fibrils associated with Alzheimer's disease and other neurodegenerative disorders
- Protein – DNA/RNA interactions in cellular membrane-less compartments and immunological diseases
- Protein-based materials in pharmaceutical biotechnology and formulation of therapeutic proteins

Competences / Infrastructure

- Microfluidics
- Biophysical assays including light scattering, chromatography, fluorescence & FTIR spectroscopy
- Chemical kinetics
- Colloid physics
- Recombinant protein expression & purification

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Biochemical Engineering

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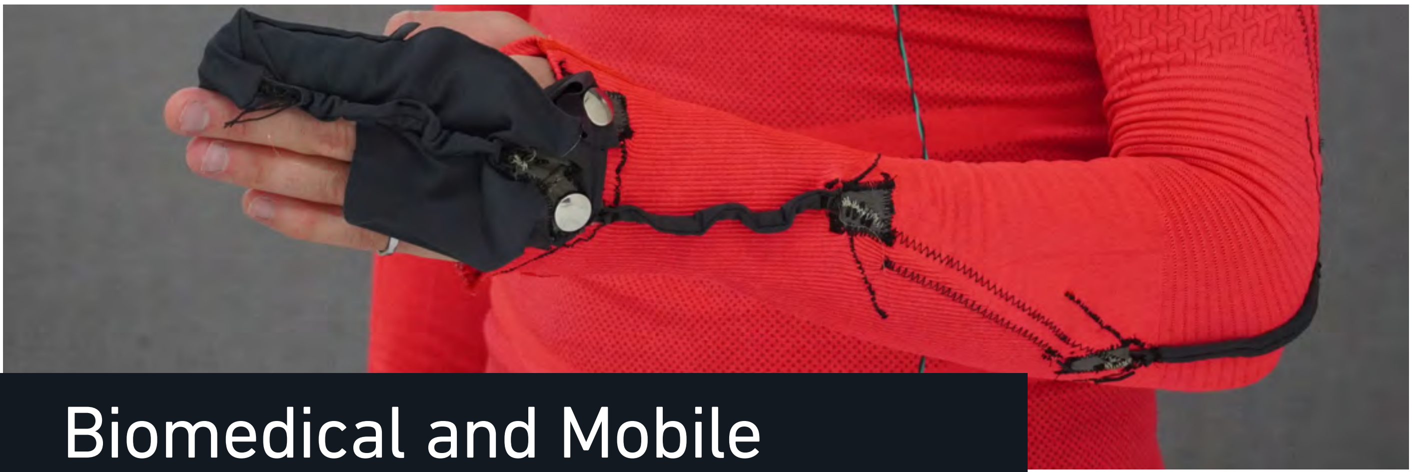
The Biochemical Engineering Laboratory is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

amyloids | protein-protein interactions
protein aggregation | therapeutic proteins



Biomedical and Mobile Health Technology

Research Profile

We aim to assist individuals to live healthier lives or to recover from neuromuscular/neurological conditions. We are designing the next generation of wearables for sports and personalized medicine.

Our research focuses primarily on wearable technology. This includes novel materials and sensors for electronic textiles (e-textiles) or other wearables, as well as innovative computational methods for processing biosignals and monitoring biomarkers detected by our sensing technology. We are working on an innovative technology to be the new building block of mobile health (mHealth). We conceive, design, and engineer innovative biosensors and wearable solutions to monitor biosignals and movements. We focus on the materials, mechanics, electronics and computing aspects of this technology. We process the collected information to build models and to study health-related behaviour.

We are in the Balgrist Campus, built in 2015. The building's architecture is geared towards the collaboration of researchers in various disciplines, developers and industrialists. It is an open, transparent building, which facilitates communication and interaction.

Competences / Infrastructure

- Biosignal- and biomarker sensing and monitoring
- Force myography (FMG)
- Human body kinematics
- AI for signal acquisition and data processing
- Functional materials for biomedical applications
- Four MRI and CT scanning machines, including a 7T MRI
- Fully equipped small molecule and polymer chemistry lab (glove box, melt-extruder, electrospinner, potentiostat/EIS)
- Rapid prototyping, high-spec 3D printers
- Electromechanical tensile testing systems and characterization systems
- Exoskeletons, instrumented treadmills, 3D motion capture systems
- Human and animal surgery

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The Biomedical and Mobile Health Technology Lab is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

wearables | sensing | artificial intelligence
smart textiles | personalized health

Biomimetic Membranes and Textiles

Research Profile

The Laboratory for Biomimetic Membranes and Textiles studies the thermal and mechanical interactions between textile materials and the human body, and develops smart fibers, textiles and membranes for body monitoring, drug delivery and tissue engineering applications. The focus is on designing and developing hybrid fibers with properties close to human skin with the aim to produce truly wearable systems for the monitoring of human vital parameters. We develop physical and numerical models of the entire human body or body parts (e.g. digital twins) to mimic human physiology as predictive tools for the physiological response to external thermal and mechanical stimuli.

Competences / Infrastructure

- Electrospinning and fiber wet spinning facilities
- Skin and body models for the study of materials-skin interactions
- Wearables for body monitoring

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Biometic Membranes and Textiles

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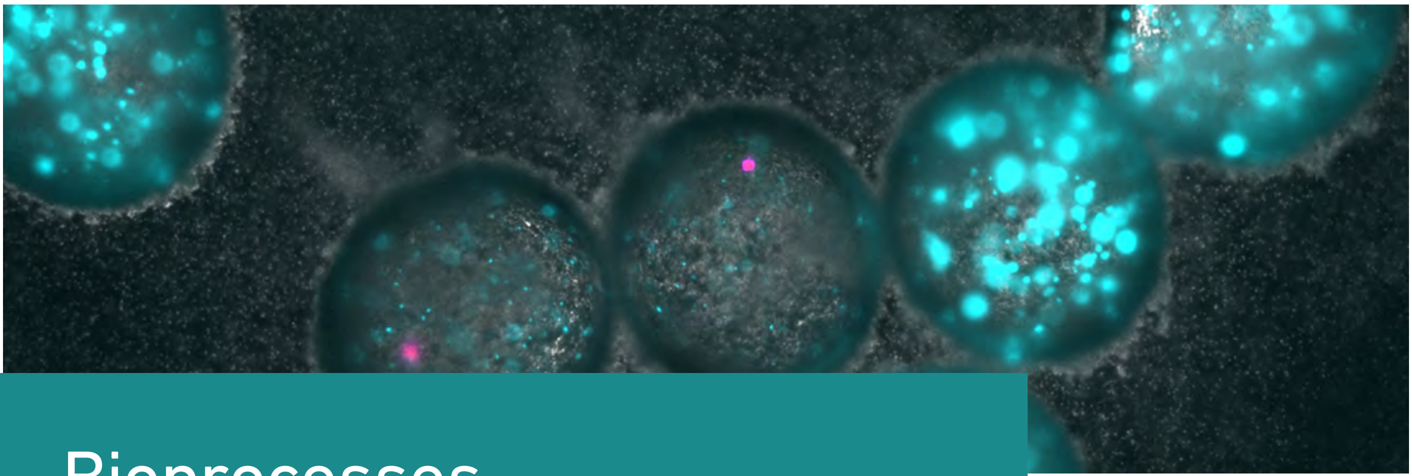
wearables | thermal physiology
smart textiles | physical skin models



Bioprocesses

Research Profile

The research of the Bioprocess Laboratory revolves around the design of novel bioprocesses for the pharmaceutical and chemical industry. We address fundamental issues in biocatalyst discovery, biocatalyst engineering and process engineering. The three main research areas are:

- Synthetic Biology: Strain and enzyme engineering for novel and better biocatalysts.
- Beyond canonical biochemistry: Catalysts with novel properties in import, catalysis (novel cofactors), and composition (non-canonical polymers).
- Discovery and Screening: Highly miniaturized and parallelized bioreactor and microfluidic technologies for strain and enzyme evolution and compound (antibiotics) discovery, including cell free protein synthesis.

Our work aims at the transfer of more and more engineering concepts into the world of bio"engineering", with the ultimate goal of converting biotechnology from a discovery science into a true engineering discipline.

Competences / Infrastructure

- Bioprocessing (fermentation, enzyme technology)
- Cell free protein synthesis
- Analytics (HPLC-MS, GC, on-line MS)
- Nanolitre reactor technology and COPAS analytics
- Microfluidic screening platforms
- Strain & enzyme engineering

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antibiotics | screening | microfluidics
nanolitre reactors | synthetic biology

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Bone Biomechanics

Research Profile

The Laboratory for Bone Biomechanics is part of the Institute for Biomechanics, which is a multidisciplinary research unit, dedicated to the biomechanical investigation of the musculoskeletal system. The Institute's interests lie in characterizing the material properties of the tissues, the quantification of their adaptation from birth to death, with disease, and due to mechanical demands. To be able to monitor risk at an early stage of pathological development, and to quantify the optimal treatment and rehabilitation are crucial for the health and welfare of society.

The Laboratory aims at providing a bridge between biologists, who have brought molecular and cellular components within the realm of engineering, and engineers, who have brought the methods of measurement, analysis, synthesis, and control within the realm of biology. More specifically, new developments in biomechanical research are aimed at the quantification and modelling of bone at the molecular, cellular, and organ level incorporating novel principles and techniques of mechanics, imaging, and in silico modelling applied to the areas of tissue engineering, regenerative medicine, systems medicine and mechanobiology. With this aim, the Laboratory develops, refines and uses biomechanical engineering tools and concepts to explore and understand musculoskeletal organization, while maintaining a philosophy of respect and compassion for all human and animal life.

Competences / Infrastructure

- 3D quantitative bioimaging: computed tomography, microscopy
- Advanced materials characterization and modelling
- Failure analysis of native and osteoporotic bone
- Mechanobiological pathways of bone adaptation
- In silico simulation of bone remodelling
- Mechanomolecular regulation of fracture healing
- Quantitative, controlled tissue engineering
- Bioprinting and biofabrication
- Organoid technology and personalized medicine

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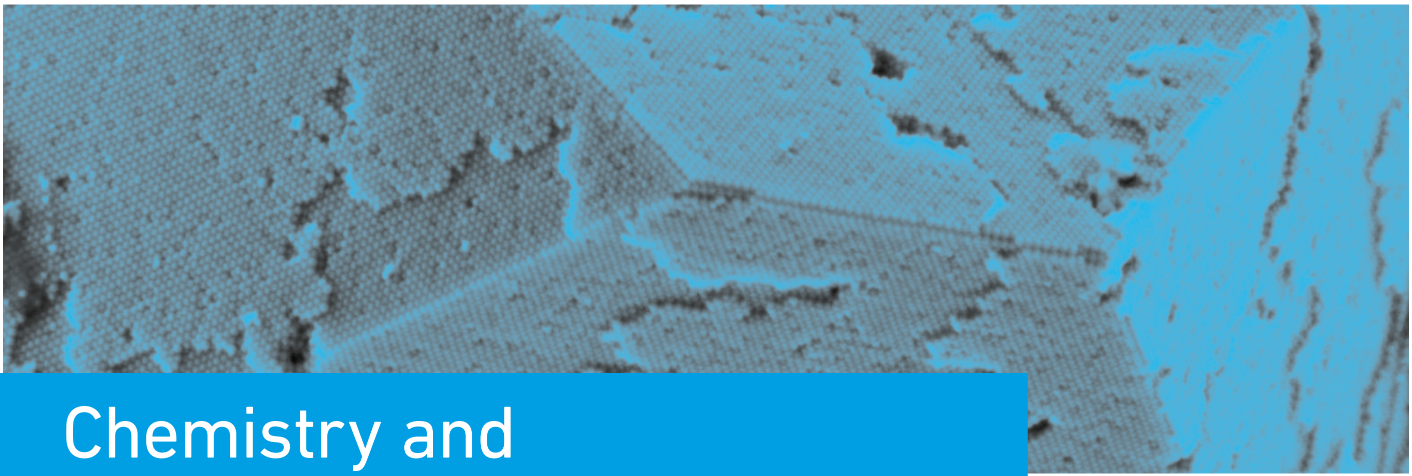
bioimaging | modelling | tissue engineering
mechanobiology | regenerative medicine
materials characterization | bioprinting

MaP Competence Center for Materials and Processes



Chemistry and Materials Design

Research Profile

The Chemistry and Materials Design Group is a newly established laboratory at the Institute for Electronics, pursuing use-inspired chemical engineering and materials science projects to improve existing technologies and to enable new functionalities. We focus on nanomaterials, such as semiconductor and metallic nanoparticles, as well as molecular precursors, particularly on robust synthetic approaches and structural characterization of these nanomaterials. Our goal is to establish the structure-property-performance relationships for these nanomaterials and employ them as building blocks for various efficient devices, engineered via bottom-up liquid-phase fabrication approaches.

Competences / Infrastructure

- Colloidal nanomaterials: robust synthetic approaches, structural characterization & applications
- X-ray scattering, electron microscopy, optical spectroscopy
- High-temperature characterization
- Optimized materials for catalytic, thermoelectric, memory, & energy-storage applications
- Synthesis upscaling

ETH Zürich
Department of Information Technology and Electrical Engineering
Chemistry and Materials Design

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The Chemistry and Materials Design Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

nanocrystals | colloidal synthesis | memory
catalysis | size and composition uniformity
phase transitions | synthesis upscaling

Complex Materials

Research Profile

Complex materials inspired or enabled by biology are in the core of our research. Biological inspiration is motivated by the fact that living organisms are able to grow materials with remarkable properties through the controlled self-assembly of building blocks at multiple length scales. Notably, living organisms achieve this feat using widely available, sustainable chemistries under mild temperatures and pressures in water.

The goal of our research is to devise and study experimental platforms to create complex materials that replicate design principles of biological structures or harness the metabolic activity of microorganisms to achieve structures and properties that are not accessible via conventional manufacturing approaches. To achieve this goal, we have focused our research on three main themes: bioinspired materials, printable materials, and living materials.

Colloidal assembly, microfluidics, and 3D printing are the main tools that we exploit to create functional complex materials. The expertise generated through our fundamental research has enabled the use of these tools to also develop new materials and manufacturing processes for specific engineering applications. This has led to the development of several new technologies that are currently being transferred to society either through licensing of intellectual property or the foundation of spin-off companies from our research group.

Competences / Infrastructure

- Microfluidic emulsification
- Bulk foaming and emulsification
- Porous materials
- Microcapsules
- Directed-assembly of colloids
- Composites with complex reinforcement architectures
- Bioinspired composites
- 3D Printing
- Fracture mechanics

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Complex Materials

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The Complex Materials Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

colloids | materials processing | living materials
microfluidics | three-dimensional printing

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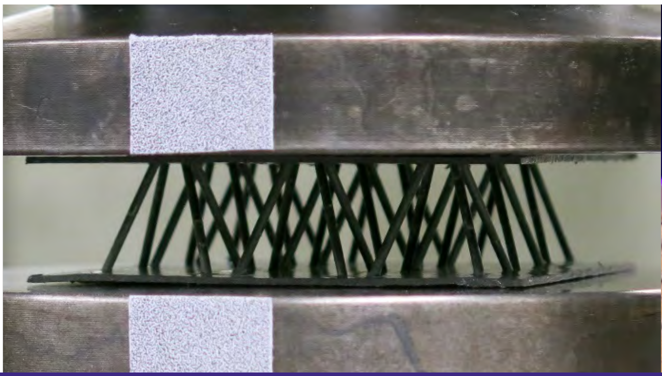
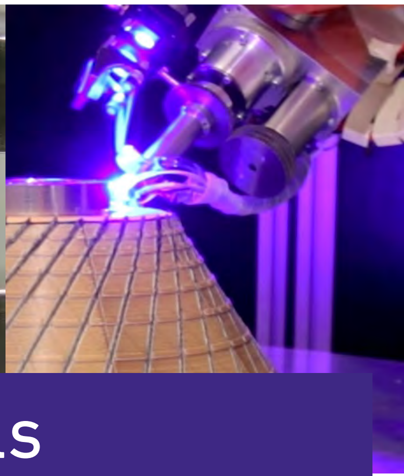
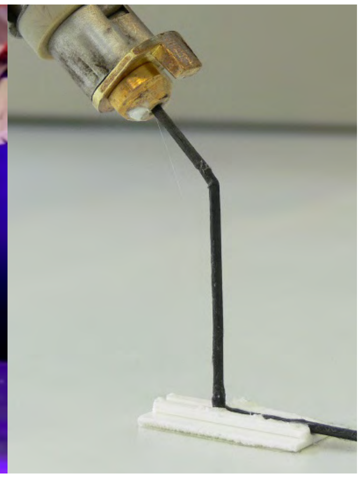

Composite Materials and Adaptive Structures

Research Profile

The CMASLab is bridging material science and engineering applications and conducts research in structural mechanics, design and fabrication processes of multi-functional lightweight structures. We are inspired by practical problems and driven by the ambition to improve efficiency, reliability and functionality of structural composite systems.
The research approach combines experimental techniques with analytical and numerical methods to understand, to simulate and to verify the physical behaviour of the developed solutions. Current research areas address problems related to:

- Shape adaptation and deployment of load carrying structures
- Vibration damping
- Multifunctional lightweight systems
- Additive manufacturing of adaptive systems
- Advanced thermoplastic composites
- Liquid Composite Molding (LCM)
- 3D printing of continuously reinforced thermoplastic composites

Competences / Infrastructure

- State of the art facilities for processing and characterization of composite materials and structures
- Modelling and design methods for optimized composite structures
- Simulation and optimization of composite materials, structures and processes
- Functional material systems for actuation, sensing and tunable material and structural properties
- Design, realization and characterization of adaptive structural systems

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Department of Mechanical and Process Engineering
Composite Materials and Adaptive Structures

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The Laboratory of Composite Materials and Adaptive Structures is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

adaptive structures | structural mechanics
morphing | polymer composites | 3D printing
processing technologies | vibration damping

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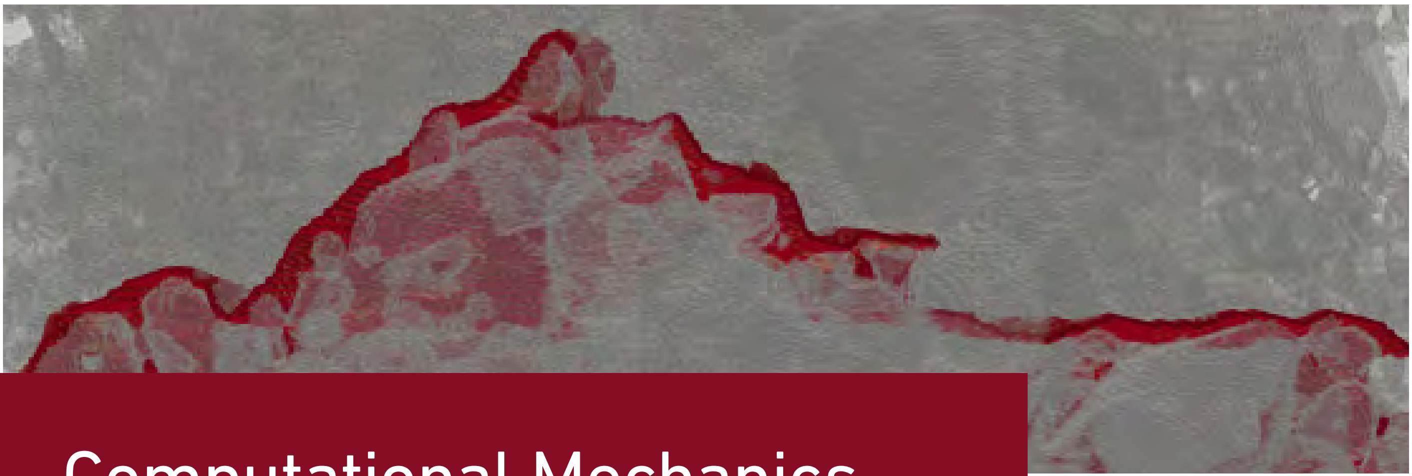

Computational Mechanics

Research Profile

The Computational Mechanics Group develops models and computational frameworks to describe complex mechanical processes, with the ultimate goal of enabling computational material, process and structural design as well as optimization. Our research deploys modern simulation methods and develops them further to meet the ever-increasing demand for accuracy and efficiency. The group also values and pursues experimental validation and, whenever needed, develops new testing setups and techniques. The focus at this moment is especially on fracture and fatigue mechanics, contact and interface mechanics, including modelling and simulation of additive manufacturing processes. Research methods are based on multiscale and multifield modelling, high-performance computing, mechanical testing including computed tomography, their related imaging techniques, and data-driven approaches.

Competences / Infrastructure

- Non-linear mechanical and coupled (thermomechanical, poromechanical, etc.) models
- Models and simulation frameworks for fracture mechanics, contact mechanics, additive manufacturing processes
- Non-linear finite element and isogeometric discretization methods
- Data-driven approaches in mechanics
- Mechanical testing, computed tomography with in-situ testing, digital image and volume correlation

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Computational Mechanics

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additive manufacturing | coupled models
data-driven | contact and fracture mechanics

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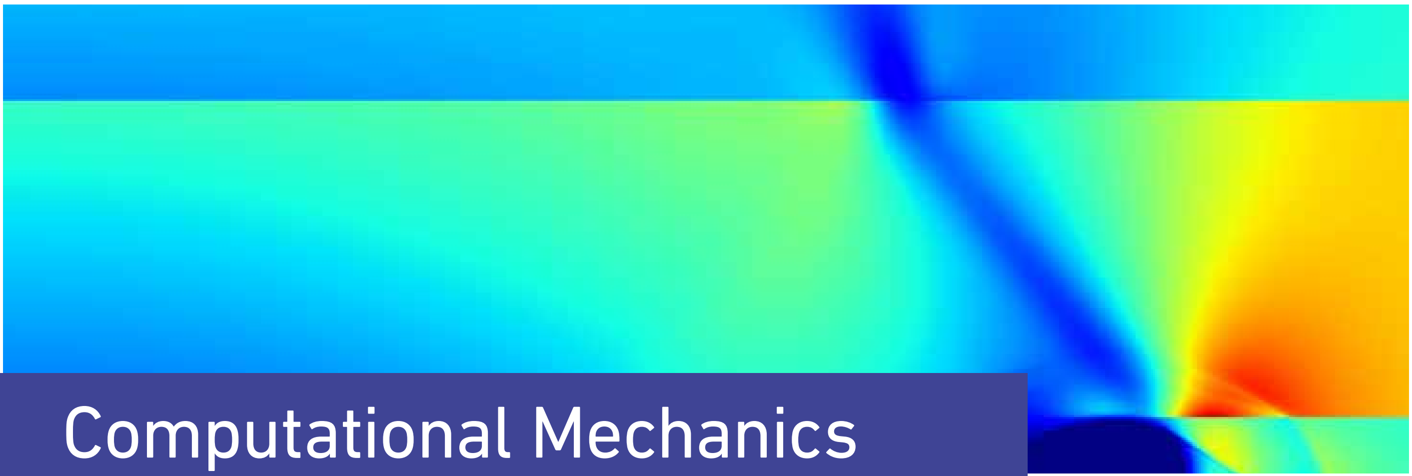

Computational Mechanics of Building Materials

Research Profile

The heterogeneous nature of biological and engineered materials and interfaces affects their macroscopic mechanical properties. These macroscopic mechanical properties are known to be linked to their microscopic material characteristics. In order to understand this link, we develop cutting-edge numerical models for material deformation and failure. Our physics-based quantitative models of complex materials, interfaces and structures are developed with the help of high-performance computing (HPC). The application of these numerical models allows us to analyse how well-designed microstructures lead to improved macroscale behaviour, to test model assumptions used in theoretical approaches, and to complement experimental studies by providing precise numerical measurements for interpretation and analysis.

We apply our numerical models to a wide range of engineering problems such as dynamic propagation of cracks in heterogeneous systems, mechanics of laboratory earthquakes, fragility of bone-collagen, and toughness properties of segmented materials.

Competences / Infrastructure

- High performance computing
- Finite element modelling and boundary element methods
- Fracture mechanics
- Mechanics of friction
- Physics-based modelling of complex materials
- Numerical and theoretical model development
- Integrating numerical and experimental methods

ETH Zürich
Department of Civil, Environmental and Geomatic Engineering
Computational Mechanics of Building Materials

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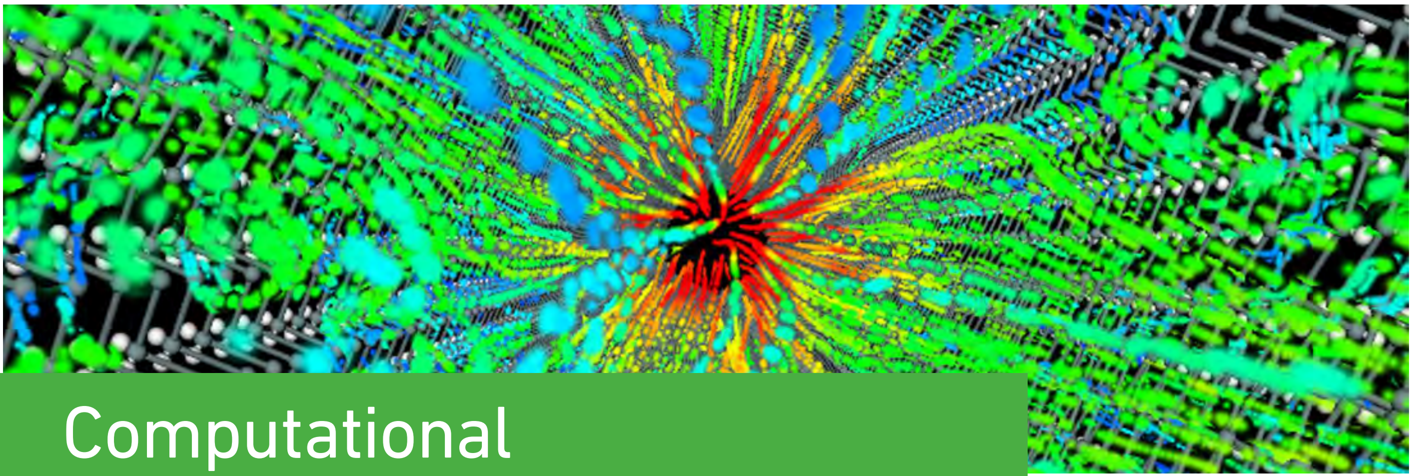
The Computational Mechanics of Building Materials Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

microstructure design | mechanical properties
material failure | high performance computing
scientific computing | numerical methods



Computational Nanoelectronics

Research Profile

Research at the Computational Nanoelectronics Group (CNG) focuses on the development and application of advanced simulation techniques to shed light on the behaviour of nanoelectronic devices, e.g. advanced field-effect transistors, non-volatile memory cells, light emitting devices, or thermoelectric generators. To address the modelling challenges that arise at the nanometre scale (energy quantization, tunnelling, geometrical confinement, or atomic granularity), the CNG has implemented several physics-based modules that were integrated into a state-of-the-art, massively parallel technology computer aided design (TCAD) tool. The latter can treat both electrical and thermal transport, in the ballistic limit or in the presence of dissipative scattering mechanisms such as electron-phonon or phonon-phonon. To handle complex materials and material combinations, our simulator can import quantities directly derived from density functional theory calculations. Several collaborations with experimentalists, at ETH and outside, have been established to support their work, facilitate the interpretation of measurements, and design next-generation components with enhanced performance.

Competences / Infrastructure

- Advanced device modelling
- TCAD of nanostructures
- Ab initio quantum transport simulations (ballistic and with scattering)
- Density functional (perturbation) theory
- Parallel numerical algorithms and high performance computing (HPC)
- Simulation of field-effect transistors, memory cells, and optoelectronic components
- Electrical and thermal transport through nanodevices

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Computational Nanoelectronics

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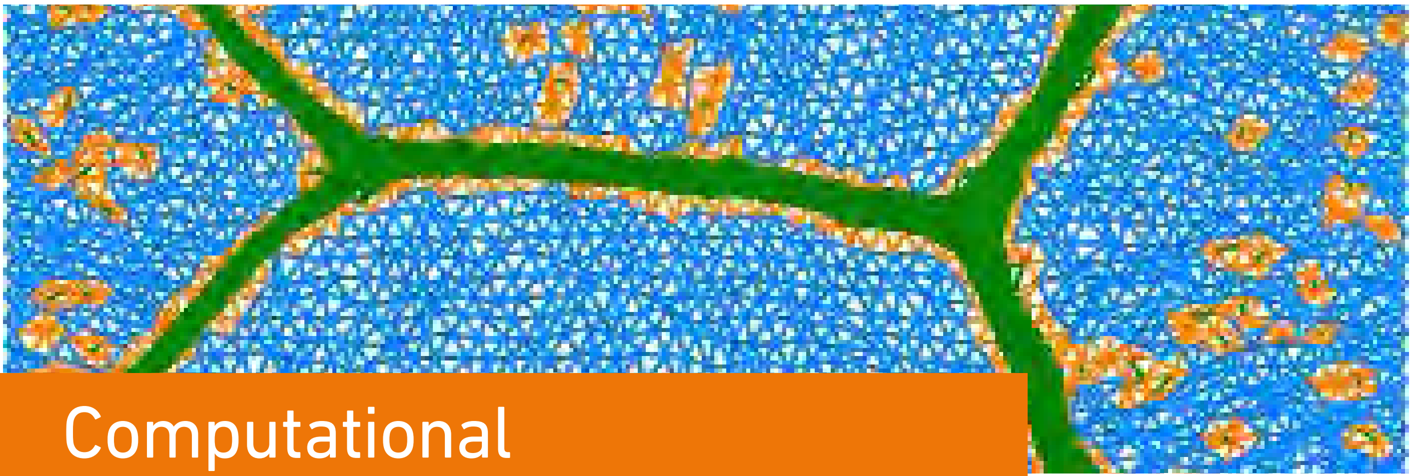
The Computational Nanoelectronics Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

ab initio | technology computer aided design
device modelling | quantum transport
nanoelectronics | high performance computing



Computational Polymer Physics

Research Profile

The Computational Polymer Physics branch of the Department of Materials performs research on the description of both equilibrium and nonequilibrium complex systems using concepts of statistical physics and simulation. Methods are developed to describe nonequilibrium characteristics such as flow- or field-induced anisotropies, viscosities, friction, magnetization, entanglements, reorganization, alignment, and many more. Therefore, these simulations are used to understand macromolecular systems such as micelles, filaments, ferrofluids, nanocomposites, biophysical systems or soft-solid networks qualitatively and quantitatively. Additionally, efficient algorithms are specifically developed for the generation, equilibration and characterization of these complex macromolecular systems. These diverse algorithms are able to be applied in a plethora of ways e.g. for the simulation of plastic deformation, cytoskeleton motion, foams & sponges, polymer dynamics or for data classification with the main goal to get insight in effects of varying the molecular structure on macroscopic behaviour.

Competences / Infrastructure

- Coarse-grained and atomistic simulations
- Monte Carlo methods
- Nonequilibrium Brownian dynamics
- Beyond-equilibrium ensembles
- Guided simulation methods
- Statistical Physics of complex liquids

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Computational Polymer Physics

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The Computational Polymer Physics is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

polymers | nonequilibrium | complex fluids
guided simulations | macromolecular systems

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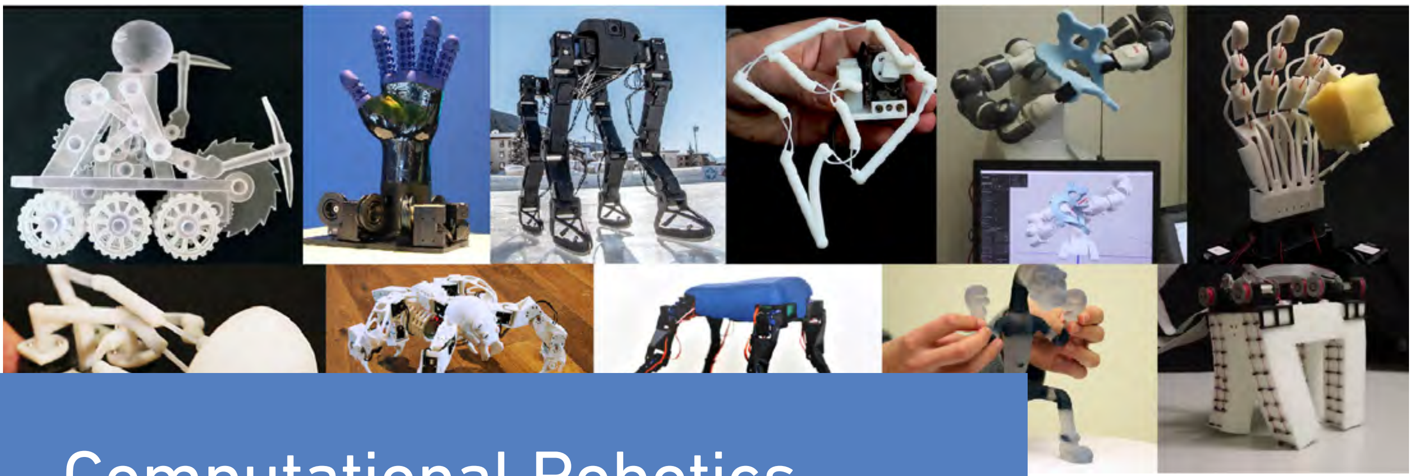

Computational Robotics

Research Profile

Bridging the fields of Computer Animation, Robotics and Computational Fabrication, Prof. Coros is establishing the foundations for algorithmic design of physical structures that generate lifelike movements. Equipped with embedded actuators and sensors, these structures will enable an abundance of possibilities for (i) robotic creatures that are composed, like living things, of precisely architected arrangements of rigid and flexible materials, (ii) lifelike animatronic figures for education and entertainment, and (iii) prosthetics and wearables that match the soft touch of the human body. Recent advances in additive manufacturing (AM) technologies are particularly exciting when it comes to these types of physical systems: if past developments are an indication, within the next decade we will be able to fabricate geometrically complex, multi-material structures that approach, at least at the macro scale, the mechanical sophistication of their biological counterparts.

To exploit the extraordinary possibilities enabled by AM to their fullest, Prof. Coros and his team are developing intelligent design software that will allow computers to reason about the fundamental relationship between form and function.

Competences / Infrastructure

- CAD tool development powered by physics-based design
- Design automation of increasingly lifelike robots
- Computational design optimization for robotic systems
- Motor control models to reproduce motion patterns of living things
- Principles of locomotion and manipulation
- 3D printable robots

ETH Zürich
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Computational Robotics

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The Computational Robotics Lab is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

computational fabrication | algorithmic design
robotics | additive manufacturing | control theory
functional systems | physics-based modelling

Digital Chemistry

Research Profile

The Digital Chemistry Laboratory is an interdisciplinary group that develops digital tools for accelerated discovery in the chemical sciences. We create predictive models that reduce the number of experiments needed to reach optimal chemical products and processes. To achieve this, we leverage methods from computational chemistry, cheminformatics and machine learning and create software tools that are both easy to use by non-experts and powerful in the hands of specialists. Our tools have so far been developed together with and for use in the pharmaceutical industry. We pursue the holy grail of computer-aided molecule and catalyst design to accelerate the transition to a sustainable chemical production.

Our research areas include:
- Reaction outcome prediction
- Reaction & process optimization
- Computer-aided molecule & catalyst design

Competences / Infrastructure

- Computational chemistry
- Cheminformatics
- Machine learning
- Data science
- Computer-aided molecular design

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Digital Chemistry

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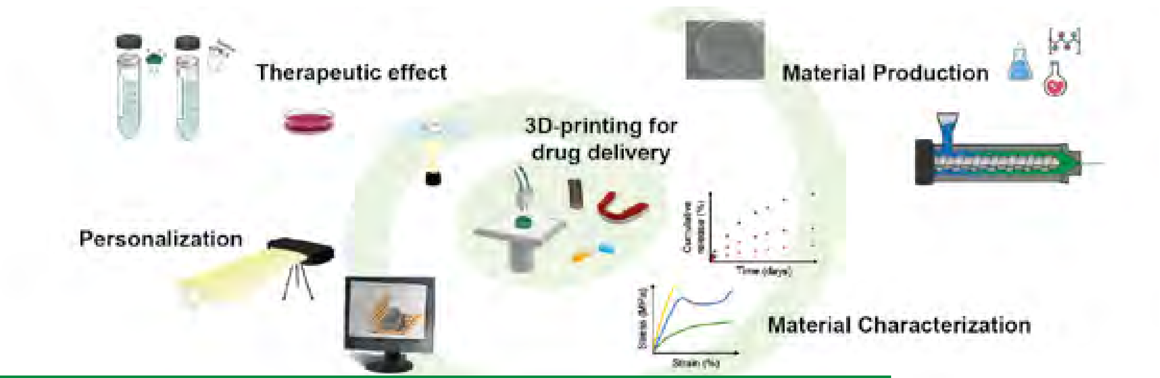
The Digital Chemistry group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

accelerated discovery | computer simulations
machine learning | cheminformatics | catalysis



Drug Formulation and Delivery

Research Profile

The development of suitable drug formulations and delivery systems remains a major challenge in the full drug product development and industrialization process. In fact, the effective and safe use of poorly-water soluble drugs such as therapeutic peptides, proteins, nucleic acids, still faces serious obstacles.

Our own research efforts are focused on main aspects of drug formulation and delivery. We are also interested in the design of new carriers and materials for various pharmaceutical applications such as gene therapy and delivery of probiotics. We cooperate closely with other groups in the basic, engineering and medical sciences for interdisciplinary innovations. Furthermore, we collaborate with the pharmaceutical industry to incorporate practical applications.

Competences / Infrastructure

- Development of liposomal formulations
- Polymer functionalization
- 3D-printing of drug-eluting medical devices
- Exosomes
- Delivery of probiotics
- Characterization of drug formulations
- Assessment of biomaterials' cytotoxicity
- Fluorescent polymer conjugates

ETH Zürich
Department of Chemistry and Applied Biosciences
Drug Formulation and Delivery

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The Drug Formulation and Delivery Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

drug delivery | drug targeting | biomaterial
biodetoxification | gel | nanopharmaceutics

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Durability of Engineering Materials

Research Profile

The aim of our research is to tackle the long-standing, multidisciplinary challenge of ensuring and forecasting the durability of metal-based structures and infrastructures exposed to corrosive environments. We perform research at the interface of corrosion/materials science and engineering.

A key focus area is the interdependence of corrosion reactions (electrochemistry) and reactive transport in porous media. This is for instance relevant for corrosion of steel in reinforced and prestressed concrete structures or for corrosion in soils.

We seek to deliver the scientific basis for:

- Mechanistic understanding of corrosion and related deterioration processes
- Measurement methods to detect and quantify corrosion and related parameters (sensors, non-destructive test (NDT) methods, robot-assisted inspection, structural health monitoring, etc.)
- Predictive models for the long-term behaviour of engineering structures exposed to their actual environments
- Methods and strategies for corrosion control and protection

Competences / Infrastructure

- Electrochemical test facilities (allowing for a wide range of electrochemical characterization and corrosion science methods in electrolytes)
- Custom-made equipment for robot-assisted local electrochemical mapping of metal surfaces
- Autoclave for electrochemical tests under high temperature and pressure environments

ETH Zürich
Department of Civil, Environmental and Geomatic Engineering
Durability of Engineering Materials

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The Durability of Engineering Materials Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

corrosion | electrochemistry | sensors | soil
NDT | transport in porous media | concrete

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Electrochemical Energy Systems

Research Profile

The Electrochemical Energy Systems Laboratory tackles challenges related to the development of the new solutions to satisfy the growing demand for energy. Complex phenomena in solids and liquids and their electrified interfaces that are associated with i) storing energy reversibly and ii) efficiently converting electrical energy into fuels are investigated. The fundamental knowledge gained is then applied to develop new materials for batteries and electrocatalysis that can deliver improved performance, cost, efficiency and safety. In addition, the laboratory is working on the design of eco-friendly energy systems that have minimal environmental impact.

Competences / Infrastructure

- Energy storage and conversion
- Electrochemical interfaces
- Materials and electrolyte design for energy applications
- Fundamental processes in electrolyte solutions
- Evolution of materials and electrode-electrolyte interfaces under applied potential

ETH Zürich
Department of Mechanical and Process Engineering
Electrochemical Energy Systems

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The Electrochemical Energy Systems Laboratory is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

electrolytes | electrocatalysis | interfaces
materials | fast-charging | green storage

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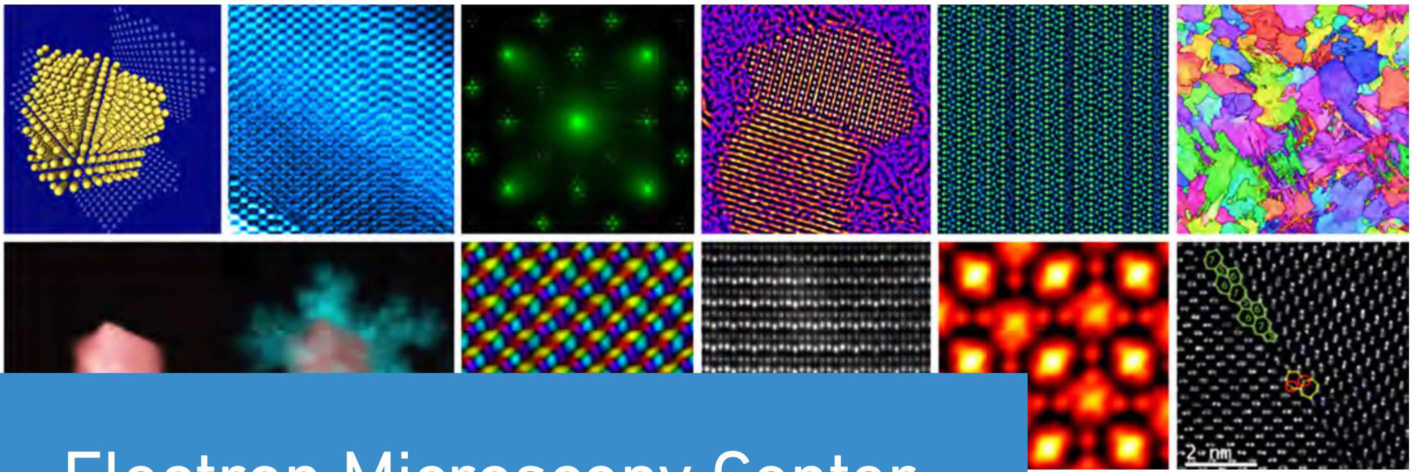

Electron Microscopy Center

Research Profile

Empa's Electron Microscopy Center located in Dübendorf conducts forefront research in the development and application of new electron microscopy techniques in materials science and acts as a consulting unit for electron microscopy in materials science. The center also offers electron microscopy services to internal and external R&D partners.

Currently we have two research foci. One is on in-situ electron microscopy in the area of liquid phase, electrochemical and gas cell measurements for investigating particle nucleation and growth, the behaviour of battery materials or, e.g., for inspecting catalytic nanoparticles and clusters in realistic conditions (temperature, gas environment). The other focus is on crystallographic aspects of functional oxides, including ferroelectrics, with the goal of exploring atomic-scale phenomena by aberration-corrected atomic-resolution imaging, which control nano- and micro-scale material properties. This research effort includes analytical and operando measurements by applying thermal and/or electrical stimuli.

Competences / Infrastructure

- TEM and STEM imaging, electron diffraction and electron tomography
- Aberration corrected, differential phase-contrast and 4D-STEM
- Off-axis and in-line electron holography
- Analytics by EDS, EELS, EFTEM and EBSD
- Liquid-phase TEM/STEM by liquid cell setups and by ionic liquids
- Gas cell TEM/STEM
- Variable temperature measurements (< ~1000°C) in TEM/STEM
- Electrical biasing and electrochemical measurements in TEM/STEM

Empa
Electron Microscopy Center
and ETH Zürich
Department of Materials

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The Electron Microscopy Center of Empa is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

atomic-scale imaging | electron microscopy | nanoscale analytics
in-situ and operando electron microscopy

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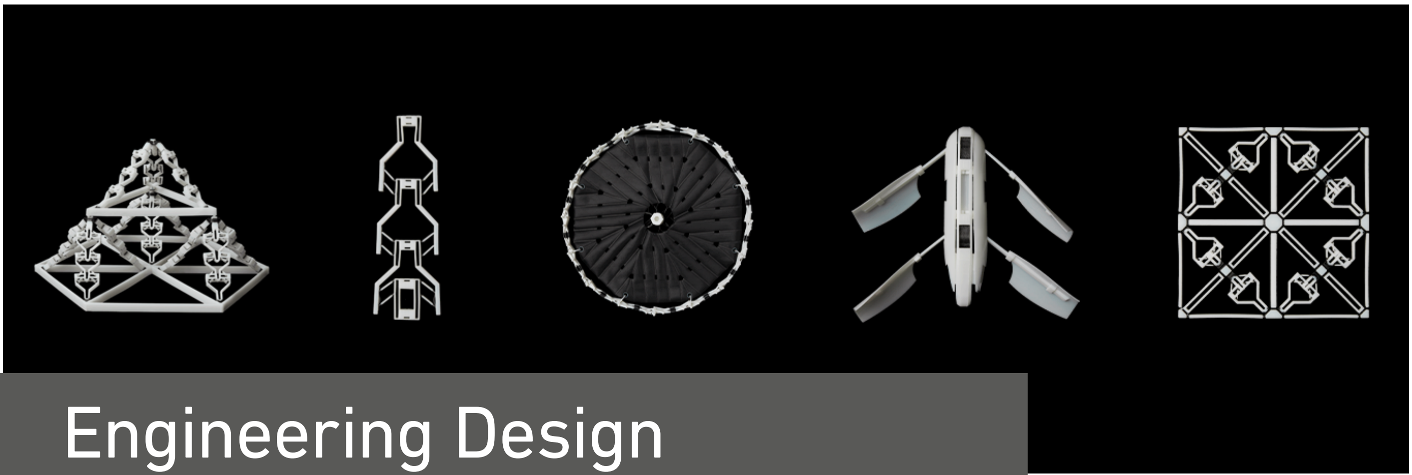

Engineering Design and Computing

Research Profile

Our research is interdisciplinary, combining engineering design, computation and digital fabrication. In product development, it considers early conceptual design phases through to the design and fabrication of novel solutions.
Current research topics to develop cutting-edge computational design methods include generative design, design automation, computational design synthesis, simulation, optimization, applied artificial intelligence and the creation of integrated methods and tools. We also have a growing expertise in computational origami. In the area of Additive Manufacture (AM), we create new Design for Additive Manufacturing (DfAM) methods that span from design heuristics to generative design and optimization methods. Finally, we investigate multi-material AM, carry out AM material characterization and design novel, active structures and systems that exploit 4D printing capabilities.
We apply our research to a wide variety of areas including the design of structures, active structures, mechanical and mechatronic systems in the consumer product, robotics, space, automotive, building and biomedical industries.

Competences / Infrastructure

- Computational Design & Optimization Methods
- Computational Origami
- Design for Additive Manufacture
- AM and Multi-Material AM including AM material characterization
- 4D Printing

ETH Zürich
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Engineering Design and Computing

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The Engineering Design and Computing Laboratory is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

computational design and optimization
design for additive manufacture
additive manufacturing | 4D printing

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Experimental Continuum Mechanics

Research Profile

Experimental methods and models are developed to study the mechanical behaviour of highly deformable biological and synthetic materials. Medical applications include diagnosis (liver pathologies, incompetence of the uterine cervix, pre-term rupture of foetal membranes), surgery planning (facial tissue models, transapical aortic valve implantation), tissue replacement and implant development (supportive mesh implants, cardiovascular stents, valves, ventricular assist devices). Characteristic features of soft biological tissue in human organs, like large strain viscoelasticity, anisotropy, and loading history dependence of the mechanical response, are determined experimentally, linked with associated features of their microstructure and described with appropriate mathematical models. Biological and biomedical material systems are studied from sub-cellular to organ level towards a better understanding of mechanobiology at different length scale. One of the objectives is to optimize the "mechanical biocompatibility" of engineered tissues, implants and prosthetics.

Other projects investigate material damage due to low cycle fatigue and creep in high temperature components, the mechanical behaviour of micro- and nanosystems, and structures made of adaptive materials.

Competences / Infrastructure

- Multiaxial in-situ mechanical testing in various microscopes
- Micro and nanoindentation of soft materials
- Deformation measurement from image analysis & features tracking
- Membrane inflation experiment for biaxial materials characterization
- Planar-two-axes material testing machine
- Tissue aspiration set-up for quasi-static in-vivo measurements
- Histology, microscopy, tissue microstructural analysis
- Biolab with bioreactors for cell mechanobiology
- Inverse problem: finite element method & constitutive models

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Experimental Continum Mechanics

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The Experimental Continuum Mechanics Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

biomechanics | mechanical biocompatibility
inverse problem | soft materials
mechanobiology | constitutive modelling

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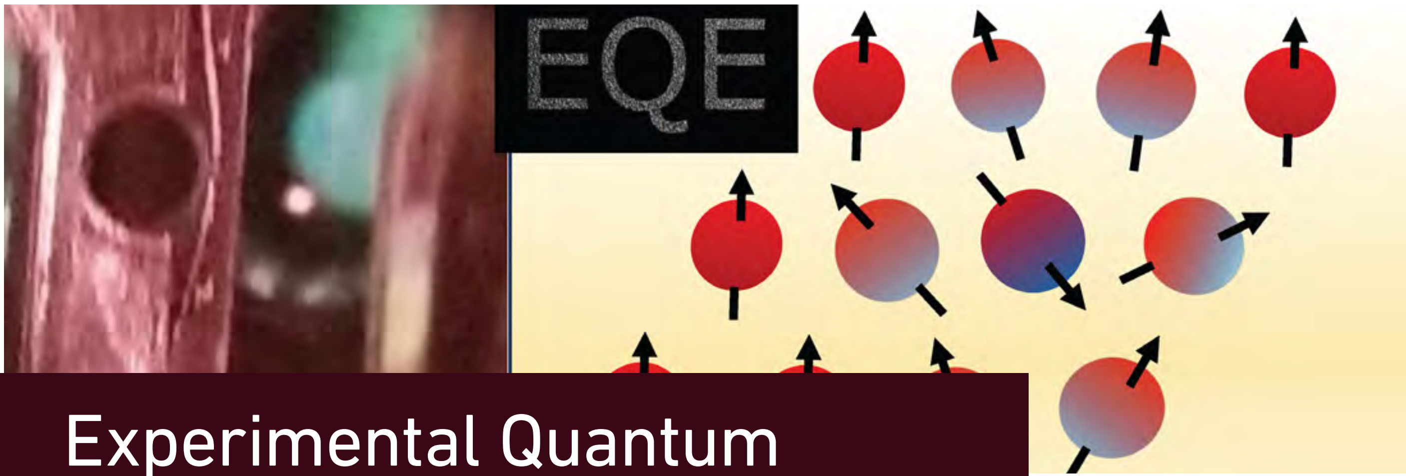

Experimental Quantum Engineering

Research Profile

The research in our group combines strategies from atomic physics and quantum optics, along with neutral cold atoms and their Rydberg states, to engineer large, fully controlled quantum many-body systems. Our primary goal is to develop new technologies for realizing fully programmable quantum many-body systems, which can explore open questions in physics and implement practical quantum technologies including general-purpose quantum computation.

The programmable quantum processor comprises an array of individually trapped atoms. By encoding spins/qubits with different atomic states, this architecture can perform analog quantum simulation on quantum spin models. One of our primary research projects focuses on the study of out-of-equilibrium dynamics in quantum spin models, as well as the exploration of novel quantum phases and their entanglement structures.

Competences / Infrastructure

- Atom cooling, trapping, manipulation, and imaging
- Laser system frequency stabilization (300nm-1000nm)
- Continuous-wave UV light generation
- Integration of optical modulators with laser systems for quantum control
- Engineering and characterization of quantum many-body states
- Development of high-speed data acquisition and analysis systems based on field programmable gate arrays (PFGA) and single-photon avalanche detectors.

ETH Zürich
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Experimental Quantum Engineering Group

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The Experimental Quantum Engineering Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area of Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

quantum information processing | quantum many-body physics | quantum materials

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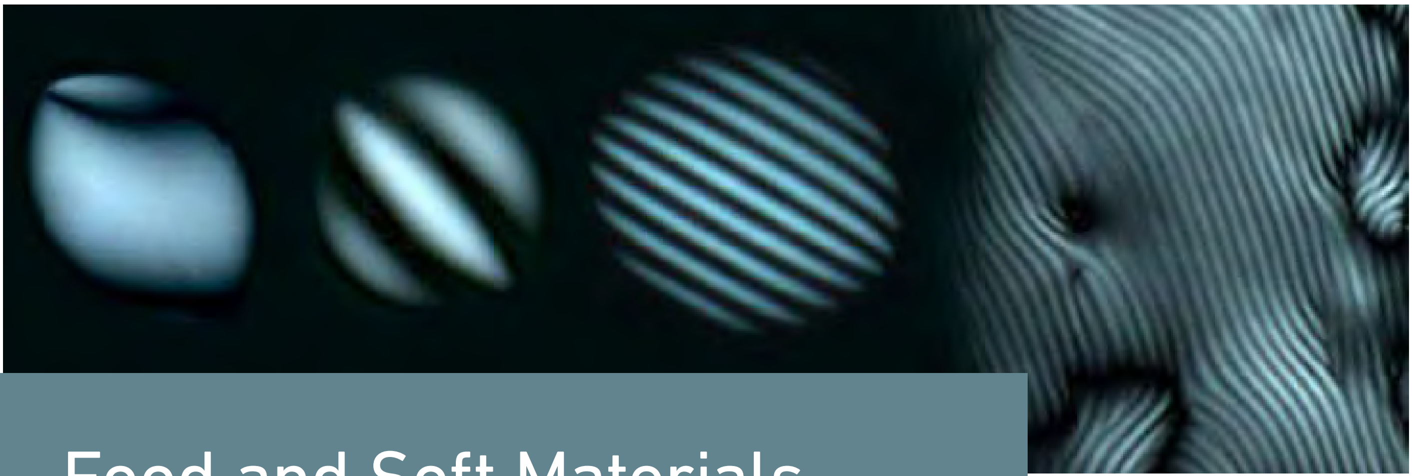

Food and Soft Materials

Research Profile

We are interested in the understanding at a very fundamental level of the structure-properties relationship of complex food systems composed by biopolymers, proteins, biocolloids and surfactants, as well as in the study of their synthetic counterparts, which are used as model reference systems. We study the self-assembly and equilibrium properties of these materials at multiple length scales, in the dilute, semi-dilute and concentrated regime from a soft condensed matter physics perspective. To study the physics regulating the self-organization of these complex fluids, we rely on experimental techniques such as atomic force and transmission electron microscopy, static and dynamic light scattering, as well as small angle x-rays and neutron scattering. We also collaborate with theoretical groups worldwide in order to unravel the self-assembly processes via modern thermodynamic theories.

Competences / Infrastructure

- Thermodynamics of biopolymers and biocolloids
- Small angle neutron scattering (SANS)
- Small, medium and wide angle x-rays scattering (SAXS, WAXS)
- Advanced light scattering techniques (DLS, SLS)
- Atomic force microscopy (AFM) and transmission electron microscopy (TEM)

ETH Zürich
Department of Health Sciences and Technology
Food and Soft Materials

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The Laboratory of Food and Soft Materials is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

surfactants | liquid crystals | polymers | proteins water (biophysics) | supramolecular materials statistical polymer physics | amyloid fibrils

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Food Process Engineering

Research Profile

We explore process-structure-property relationships in food and biomaterials from the molecular to the macroscopic level by connecting the areas of process engineering and food material sciences. We focus on the kinetics of structure transformation under processing conditions and thereby derive design criteria to tailor novel processes and products.

Our approach to tailor-make food and biomaterial structures directly relates to human health, as well as to quality and safety of foods. Current research topics include novel processing methodologies for hierarchical structure generation and gastro-intestinal engineering to optimise structure disintegration and functional release.

Our scientific approach covers experimental processing set-ups from microfluidics to pilot scale, and soft material characterisation techniques.

Competences / Infrastructure

- Soft matter physical analytics (bulk and interfacial rheology), scattering (SALS, SANS, SAXS, WAXS), calorimetry, microscopy (SEM, TEM, CLSM incl. mPIV)
- Flow processing of tailored functional food and biostructures (multiple dispersion processing, encapsulation, spray drying & chilling, extrusion processing)
- Fluid dynamics and structure engineering of the human gastro-intestinal tract

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Department of Health Sciences and Technology
Food Process Engineering

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functional biostructure and food processing
microfluidics | soft matter physics
extrusion | bulk and interfacial rheology

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Functional Inorganic Materials

Research Profile

Linking basic and applied research in the areas of synthesis, self-organisation and applications of inorganic functional materials. Focus on challenges related to the chemistry, physics and applications of inorganic nanostructures. Internationally most recognized is the first report on the synthesis of inorganic nanocrystals (NCs) of lead halide perovskites and their use as classical and quantum light sources. Synthetic work and rigorous materials characterization are the cornerstones of our research. Another focal point is the discovery of novel luminescent materials comprising exclusively non-toxic elements. A distinctly different research direction concerns novel materials and concepts for electrochemical energy storage. In particular, aluminium-based batteries are researched as a low-cost solution for stationary energy storage.

Competences / Infrastructure

- Solution- and solid-state synthesis of novel inorganic materials and nanomaterials
- Structural, optical and electronic characterization of inorganic nanomaterials
- Development and testing of novel electrode materials for Li-, Na- and Mg-ion batteries

ETH Zürich
Department of Chemistry and Applied Biosciences
Functional Inorganic Materials

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The Kovalenko Lab is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

nanocrystals | optoelectronics | self-assembly
synthesis | energy conversion | energy storage

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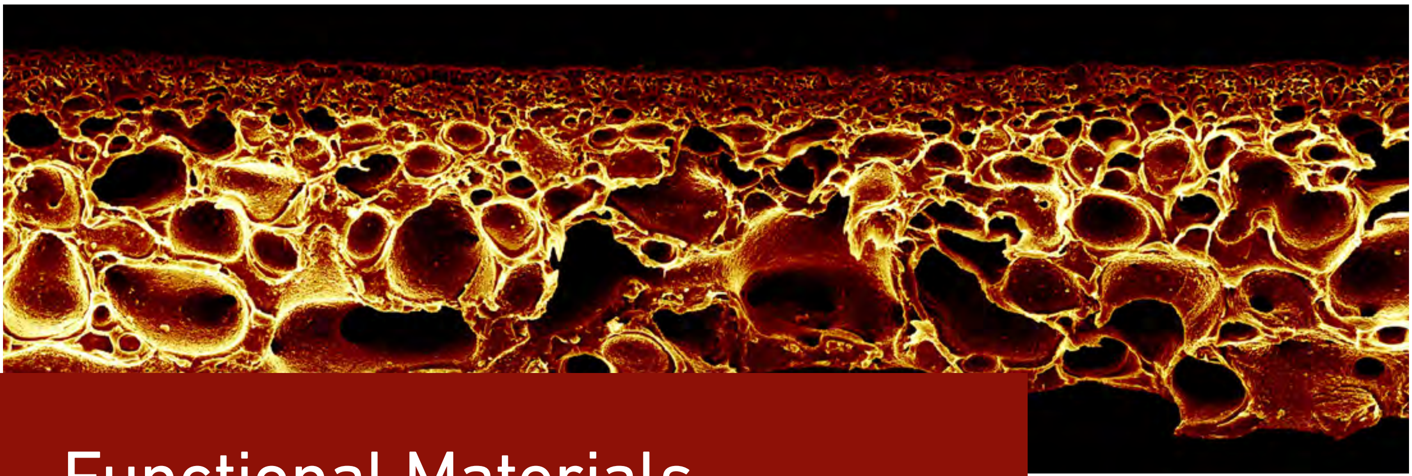

Functional Materials

Research Profile

Our research targets real application challenges in industrial and medical applications of functional materials. Originating from our work on nanoparticles, we now develop nanoporous membranes for water purification ultimately aiming to bring the technical process to developing countries. By combining microorganisms with 2D materials into foils or membranes, we fabricate so-called biosensors to test for water quality. The availability of stable, chemically functionalized nanomagnets allows us to make magnetic reagents for filtration and separation. Additionally, we develop soft machines since 2013 and work on a soft total artificial heart since 2014, using combinations of traditional manufacturing and novel concepts such as lost mould casting of 3D printed structures.

The Functional Materials Laboratory Head Professor Wendelin Stark serves on the UN environment programme Global Environment Outlook 6 (GEO-6) Joint Scientific Advisory Panel, the largest ever done independent assessment of the global state of the environment.

Competences / Infrastructure

- Membrane preparation
- Biosensor fabrication
- Chemical device development
- Chemical functionalization of graphene

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Functional Materials

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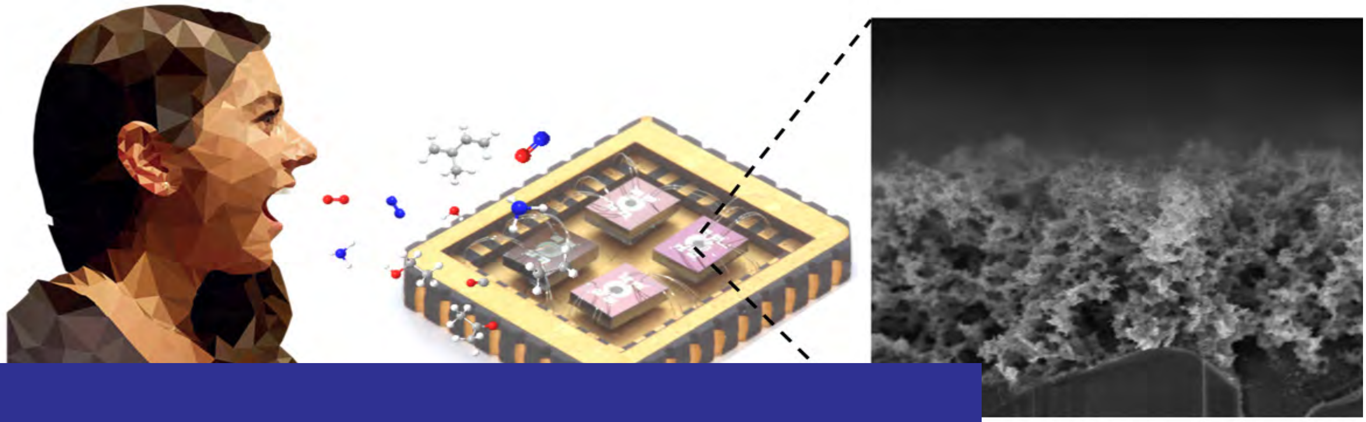
nanomagnets | biomaterials | graphene
water purification | nanoparticles



Human-Centered Sensing

Research Profile

The Human-Centered Sensing Laboratory works at the interface between chemistry, physics, and engineering to equip next-generation electronics with the sense of smell. Leveraging nanotechnology, we investigate new concepts in chemical sensing and foster their integration into wearable or handheld devices for health, food and environmental monitoring to improve human well-being. We offer a unique bouquet of fundamental and applied research on sensor technologies to respond to society's needs, and profess on the interdisciplinary education of students in chemical, mechanical, and biomedical engineering.

Competences / Infrastructure

- Micro- and nanoscaled systems
- Surface phenomena and molecular transport
- Chemical sensing and signal processing
- Wearable/mobile devices
- Health and environmental sensing

ETH Zürich
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Human-Centered Sensing Laboratory

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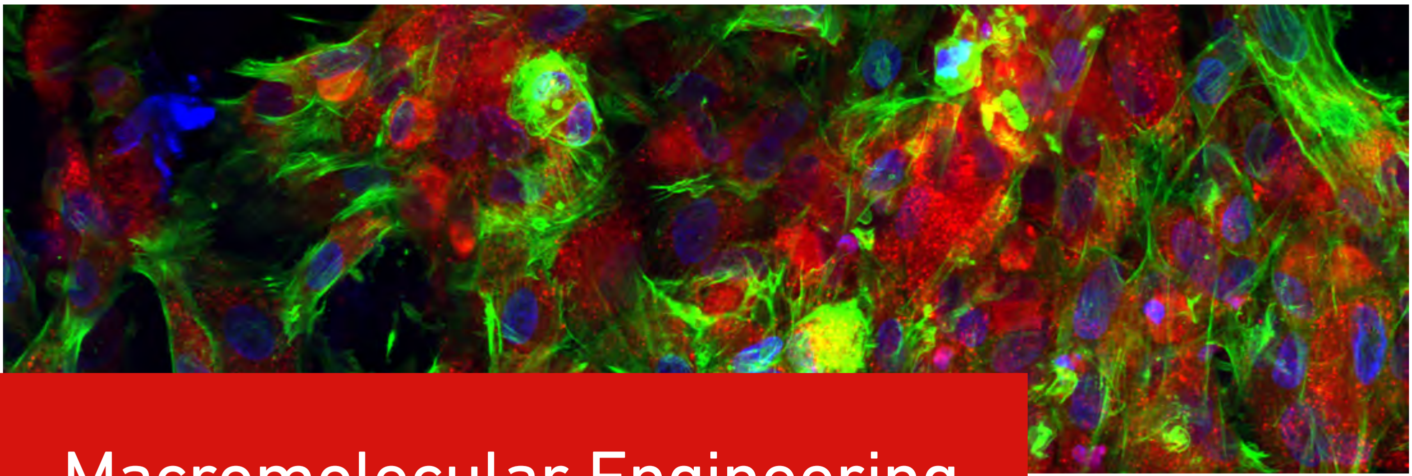
nanotechnology | analytical chemistry
electronics | chemoresponsive materials



Macromolecular Engineering

Research Profile

In the Macromolecular Engineering Laboratory, we exploit the unique properties of macromolecules for the synthesis and fabrication of soft materials with a particular emphasis on biomedical applications. Research in the lab integrates concepts and techniques from chemical engineering, synthetic chemistry, materials science, and biology to design and assemble responsive (bio)materials. We tailor structural and chemical details at the molecular scale to enable predictive and tunable control over emergent macroscale properties. Our user-programmable and responsive materials are employed to understand fundamental processes in biology and materials science as well as translated to address clinical problems in the fields of drug delivery, regenerative medicine, and biomedical diagnostics.

Specific focus areas of the lab include the design of hydrogels for 3D cell culture and drug delivery, tissue engineering, photopolymerization and photoresponsive materials, nanoformulation, biofabrication of tissue models for drug screening, and microfabrication of hydrogel biomaterials.

Competences / Infrastructure

- Hydrogel synthesis and characterization
- Cell culture including 3D culture
- Polymer synthesis and characterization
- Nanoparticle synthesis
- Drug delivery
- Rheology
- 3D printing / additive manufacturing
- Tissue engineering / regenerative medicine

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Macromolecular Engineering

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hydrogels | biomaterials | biofabrication
drug delivery | 3D cellular models
tissue engineering | photopolymerization

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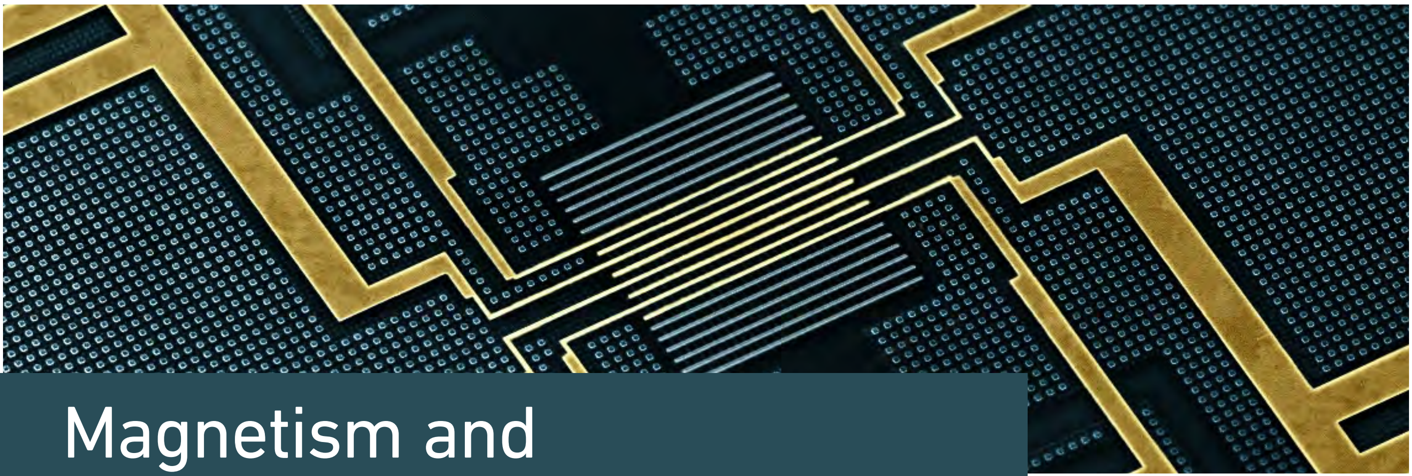

Magnetism and Interface Physics

Research Profile

Our group investigates magnetic materials and interface systems for applications in magnetoelectronics, such as magnetic memories and sensors. Our research also focuses on the study of new physical properties emerging from the interplay of spin-orbit coupling, spin relaxation, and electron transport as well as on the fabrication of new materials (multilayers, functional metal-oxide and metal-organic thin films, nanoparticles, nanostructures) and their characterization using advanced techniques such as synchrotron radiation spectroscopy, scanning probe microscopy, magneto-optics, and electrical probes. Current areas of expertise include:

- Deposition and characterization of thin film multilayer systems
- Design of spintronic devices
- Development of novel magnetic probes
- Magnetization measurements by local and nonlocal methods
- Magnetoresistance and Hall effects
- Spin torques
- Single atom magnets

Competences / Infrastructure

- Sputter deposition and molecular beam epitaxy of thin films
- Magnetotransport measurements (dc, ac, pulsed, time-resolved)
- Atomic and magnetic force microscopy (AFM/MFM)
- Vibrating sample magnetometry (VSM)
- Magneto-optic Kerr effect (MOKE)
- Scanning tunnelling microscopy and spectroscopy (STM)
- X-ray absorption and magnetic dichroism, X-ray microscopy (XAS, XMCD, XPEEM, STXM)

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Magnetism and Interface Physics

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magnetism | PVD | spintronics | thin films
STM | solid state physics | multilayers | MB
nanostructures | MOKE | surfaces | XMCD

MaP Competence Center for
Materials and Processes

Materials and Device Engineering

Research Profile

Development and implementation of advanced analytical techniques combined with theory, to study the electronic and ionic transport properties in solution-processed structures composed of nanoscale materials. The understanding gained from these studies is then applied for the rational design of new materials and device architectures for optoelectronic and electrochemical applications that harness the novel form factors and properties provided by nano-sized materials. Focus on design as well as fabrication of solid state energy-related devices at each point in the energy life cycle – collection, storage, and usage – including solar cells, lithium ion batteries, and photonic crystals with enhanced performance. Guided by insights from proof-of-concept devices, methods for low cost and high throughput manufacturing are investigated, with a particular focus on the development of novel techniques for industrial-scale materials growth and deposition.

Competences / Infrastructure

- Nanoparticle and battery material synthesis: N_2 Schlenk line, continuously stirring tank reactor
- Thin film deposition and characterization: interconnected growth system including two N_2 gloveboxes for sputtering and evaporation metals, metal oxides, and organics
- X-ray diffractometer: grazing incidence diffraction, high temperature and electrochemical cells for in-situ measurements
- Optical device characterization: streak camera, microscopes, spectrometers, solar simulator, diode lasers, and electronics
- Battery assembly and testing: battery electrode coating systems, coin and pouch cell assembly in Ar gloveboxes, electrochemical battery testing, and tomographic imaging (X-ray microscopy & FIB-SEM)
- Multiscale modelling of materials and energy devices

The Materials and Device Engineering Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

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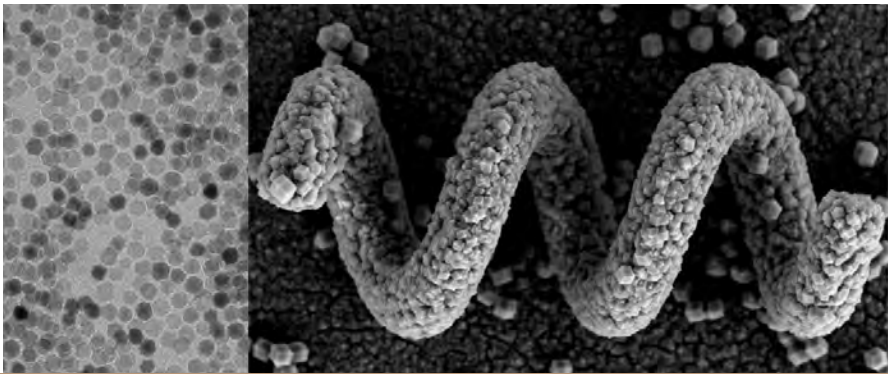
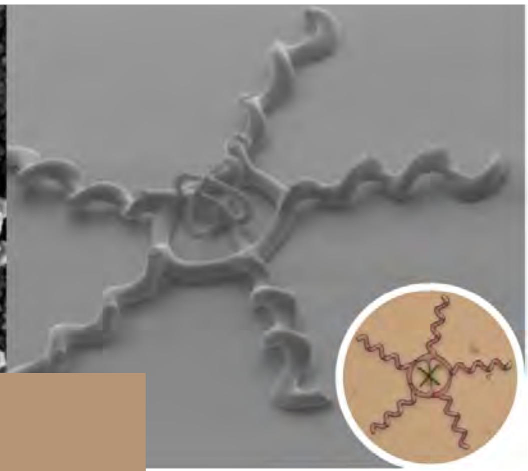
nanostructured materials | optoelectronics
electrochemistry | solid state devices
lithium ion batteries | solar cell

Materials for Robotics

Research Profile

As part of the Multi-Scale Robotics Lab, the Materials for Robotics division is focused both in fundamental questions and applied research in materials for robotics applications, with a focus on micro- and nanorobotic platforms for biomedical applications. Our mission is to develop manufacturing strategies and materials to create several types of robotic micro- and nanotools, including both wireless small-scale devices and tethered systems such as catheters. To accomplish our objectives, we capitalize on an extensive variety of methods such as 2D- and 3D-lithography, atomic layer deposition, template-assisted electrochemical processing, microfluidics, or 3D printing, among others. We design manufacturing processes that enable batch production, are compatible with other fabrication approaches, and they allow for the integration or combination of a wide variety of materials. We also employ microfluidic tools that enable mimicking Nature's reaction-diffusion processes to facilitate a control over material processing. Our primary focus is in advanced magnetic, piezoelectric and magnetoelectric materials for cell electrostimulation. We also design tailored materials including soft materials with stimuli-responsive capabilities for targeted drug delivery applications.

Competences / Infrastructure

- Nanomaterial synthesis
- Electrodeposition, anodization and electrochemical characterization
- Atomic force microscopy including piezoresposive force microscopy
- Two-photon polymerization for 3D printing of functional hierarchical structures/templates
- Microfluidic-assisted fabrication and characterization of soft microrobots
- In vitro biocompatibility tests for novel materials

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Materials for Robotics

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micro- & nanorobotics | nanomaterials
magnetic & piezoelectric materials | 3D printing

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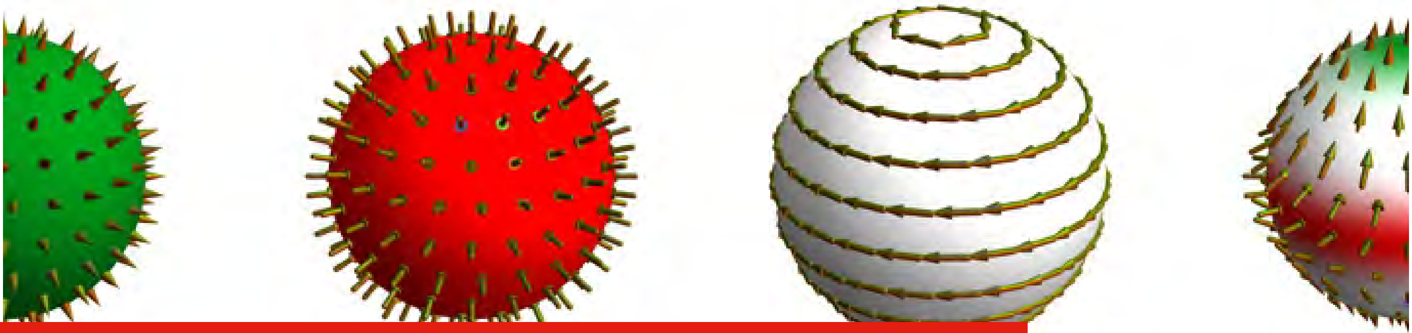

Materials Theory

Research Profile

Research in the Materials Theory Group uses a combination of first-principles and phenomenological theoretical techniques to study the fundamental physics of novel materials that have potential technological importance. Projects combine development of new theoretical methods, application of the methods to existing materials, design of new materials with specific functionalities and subsequent synthesis of the "designer materials". Specific materials classes of interest are:

- Transition-metal-oxides with "strong correlations", in which the behaviour of each electron explicitly influences that of the others.
- Contra-indicated multifunctional materials, which combine multiple, technologically desirable functionalities that tend not to co-exist.
- Multiferroics, which are simultaneously ferromagnetic, ferroelectric and ferroelastic and/or ferrotoroidic.
- Materials with multiple coupled or competing instabilities, which in turn show strong responses to electric or magnetic fields or strain.
- Materials with hidden, entangled or resonating order.
- Room-temperature superconductors.

Competences / Infrastructure

- Calculation of structure and properties of functional materials
- First-principles design of new materials with specific functionalities
- Oxide single-crystal growth

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Materials Theory

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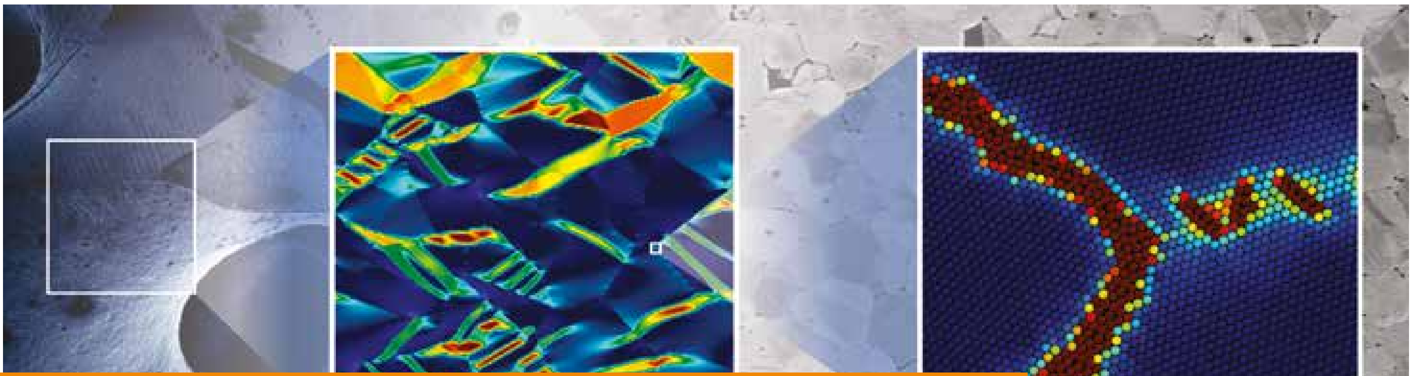
density functional theory | complex oxides
multiferroics | strongly correlated materials



Mechanics and Materials

Research Profile

The goal of the Mechanics and Materials Laboratory is a fundamental, predictive understanding of the link between material properties and the underlying microstructural architectures across various length and time scales. To this end, new theoretical models and computational tools are developed and applied to both existing materials (primarily metals, ceramics and composites, but also biological materials) as well as architected materials or metamaterials with tailored , exotic, or extreme properties. Additive manufacturing and experimental material characterization complement theory and simulations. Specific research directions include:

- Scale-bridging simulation techniques from the atomic level all the way up to devices and structures.
- Micromechanical models for metals and ceramics to understand their mechanical behaviour and failure mechanisms.
- Advanced computational techniques that exploit high-performance computing and address problems involving severe deformation.
- Active materials that respond to mechanical, thermal, electric or magnetic stimuli with a focus on ferroelectrics.
- Architected (meta-)materials with tailored properties by optimizing their small-scale architecture.
- Modeling of slender structures.
- Mimicking atomic-scale material behaviour in structural-level architected materials.
- Exploiting machine learning for computational modeling, property prediction, and inverse design.

Competences / Infrastructure

- Multiscale modelling techniques
- Electro-thermo-mechanical characterization of functional materials
- Models for metal plasticity and processing
- High-performance computational techniques
- Finite element technology and meshless techniques
- Architected materials
- Wave motion in architected materials
- Additive manufacturing and 3D-printing
- Machine learning for (architected) materials discovery

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Mechanics and Materials Laboratory

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The Mechanics and Materials Laboratory is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

multiscale material modelling | wave motion
functional materials | architected materials

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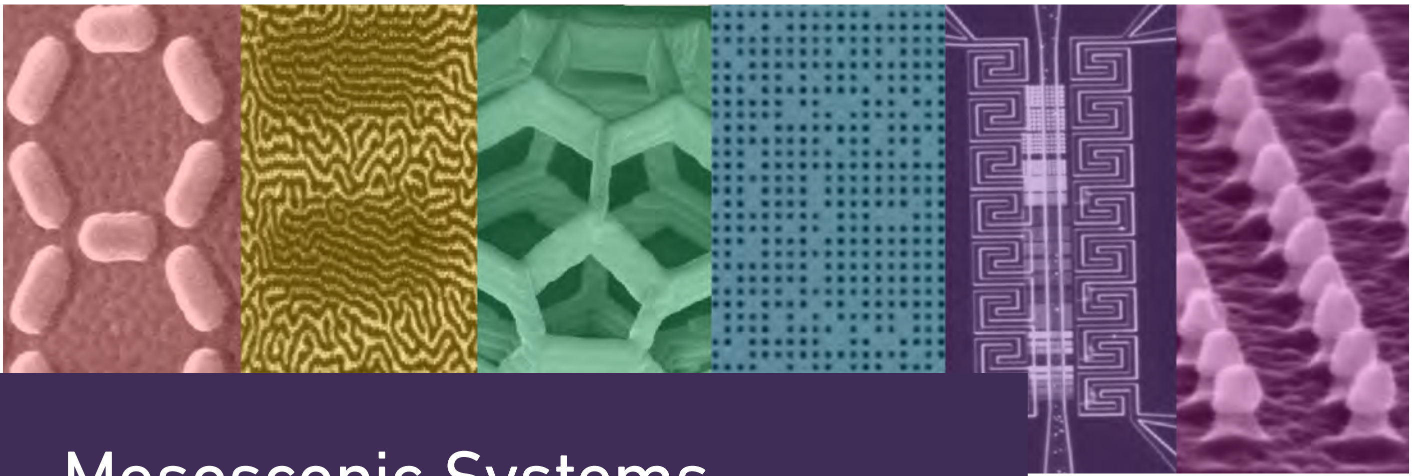

Mesoscopic Systems

Research Profile

The Laboratory for Mesoscopic Systems based at the Paul Scherrer Institute (PSI) is a joint laboratory between the ETH Zurich and PSI. Our research is directed towards novel magnetic thin films and nanostructures, which we investigate with the large scale facilities at PSI. Mesoscopic magnetic systems are of technological importance for a variety of industrial applications including magnetic data storage, magnetic random access memory (MRAM), magnetic logic and data transfer, as well as miniaturized sensor and actuator elements for microfluidics, biomedical and space applications.
Using synchrotron X-ray microscopy techniques, we can perform detailed element specific observations of magnetic domains, both ferromagnetic and antiferromagnetic, as well as strain domains in ferroelectric materials. We also use X-ray and neutron scattering, and low energy muons to characterise large assemblies of nanoscale magnets, and have developed X-ray tomography for the characterisation of the structure, chemistry and magnetism of materials in 3D. We perform this characterisation at different timescales ranging from seconds down to picoseconds. We currently focus on:

- Metamaterials incorporating arrays of coupled nanoscale magnets
- Manufacture and characterization of 3D mesoscopic magnetic systems
- Micro/nanoscale devices for computing and robotics applications
- Hybrid systems with two or more functional components

Competences / Infrastructure

- Thin film and multilayer deposition (metals & oxides)
- Nanofabrication/lithography, 3D lithography
- Lab-based magnetic and magnetotransport measurements: NanoMOKE, Kerr Microscopy, Vibrating Sample Magnetometry, Physical Properties Measurement System, Magnetic Force Microscopy
- Imaging of magnetization dynamics with synchrotron X-rays
- Synchrotron X-ray & neutron scattering, and low energy muon spectroscopy
- Ultrafast experiments with lab-based femtosecond laser setup and at X-ray free electron laser facilities

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Department of Materials
Mesoscopic Systems

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The Laboratory for Mesoscopic Systems is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

Magnetic thin films | nanostructures & devices | large scale facility experiments

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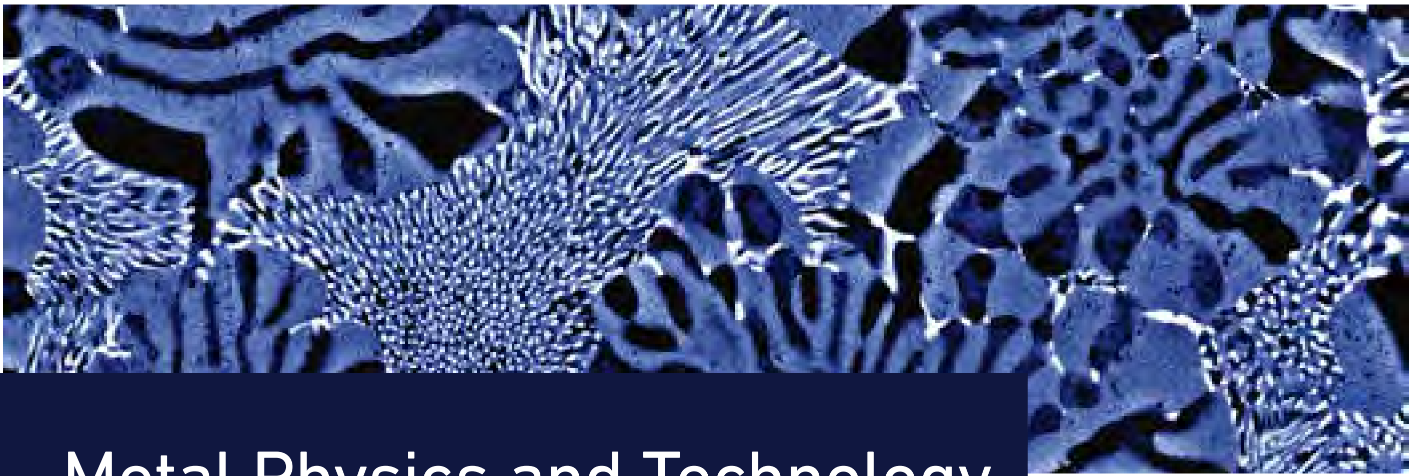

Metal Physics and Technology

Research Profile

The Laboratory of Metal Physics and Technology (LMPT) carries out research and teaching in areas ranging from basic science to technology, mostly in metals-related fields. It is the aim of the LMPT to develop new metallic materials, and to find and explore novel phenomena in metal physics and technology via detailed characterization of these materials and modelling. Research focuses on the following areas:

› Bulk metallic glasses, comprising a new class of amorphous alloys that reveal fundamentally new properties because of their disordered atomic arrangement.
› Metallic biomaterials, in particular biodegradable magnesium alloys for temporary implant applications.
› Magnetic alloys and nanomagnets that reveal fundamentally modified magnetic properties due to their reduced internal length scales.
› Modern aspects of metallurgy, in particular the atomic to nanoscale characterization of alloys, using TEM, synchrotron X-ray diffraction, and atom probe tomography.
› Development of new light-metal alloys and related processing technology.

Competences / Infrastructure

› Bulk metallic glasses
› Metallic biomaterials
› Magnetic alloys and nanomagnets
› Modern aspects of metallurgy
› Light metals

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Metal Physics and Technology

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metallic glasses | biomaterials | magnetism
modern metallurgy | alloys | light metals

Micro- and Nanosystems

Research Profile

In the Micro- and Nanosystems Group, we carry out research in ultra-low power sensor systems for applications in environmental sensing, medical implants and robotics. We explore new materials for nano-electromechanical systems, for example carbon nanotubes, and develop new concepts for MEMS and thermoelectric devices. Silicon and microsystems process technologies are key for our research. We use ETH Zurich's cleanroom facilities and technology platforms FIRST, BRNC and ScopeM. Our current research foci are:

- Carbon nanotube sensors and fabrication methods for environmental sensors.
- Thermoelectric and memristive materials for zero power sensor systems.
- Sensor integration for new generation medical implants and robotics.

Competences / Infrastructure

- Process development and integration of new functional materials on the micro- and nanoscale
- FIRST, CLA-FIRST and BRNC clean room facilities
- Carbon nanotube growth and integration for advanced manufacturing processes
- Raman spectroscopy for carbon nanotube process control
- Flexible MEMS technology for scalable device fabrication
- Implantable and zero power sensor concepts
- Material and device characterization

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Micro- and Nanosystems

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The Micro- and Nanosystems Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

carbon nanotubes | MEMS | flexible MEMS
polymer MEMS | thermoelectric microgenerators
NEMS | microsystems | implantable sensors

Microfluidics and Nanoscale Science

Research Profile

Our research group is engaged in a broad range of activities in the general area of microfluidics and nanoscale science. At a primary level, our interest in miniaturized analytical systems is stimulated by the fact that physical processes can be more easily controlled and harnessed when instrumental dimensions are reduced to the micron scale. Indeed, it is well recognized that when compared to macroscale technology, microfluidic systems engender a number of distinct advantages with respect to speed, analytical throughput, reagent usage, process control, automation and operational and configurational flexibility. In general terms, such systems define new operational paradigms and provide predictions about how molecular synthesis and analysis might be revolutionized in the coming years.

Our primary specializations include the development of microfluidic devices for high-throughput biological and chemical analysis, ultra-sensitive optical detection techniques, nanofluidic reaction systems for chemical synthesis, novel methods for nanoparticle synthesis, the exploitation of semiconducting materials in diagnostic applications, the development of intelligent microfluidics and the processing of living organisms.

Competences / Infrastructure

- Continuous and segmented flow microfluidics
- 3D printing
- Nanomaterial synthesis
- Assay miniaturisation
- Droplet-based microfluidics
- High-speed optical imaging
- Single cell/organism processing
- Point-of-care diagnostics
- Fungal interactions

ETH Zürich
Department of Chemistry and Applied Biosciences
Microfluidics and Nanoscale Science

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The deMello Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

microfluidics | high-throughput | droplets
machine learning | artificial intelligence
nanoparticles | deep learning | single cells

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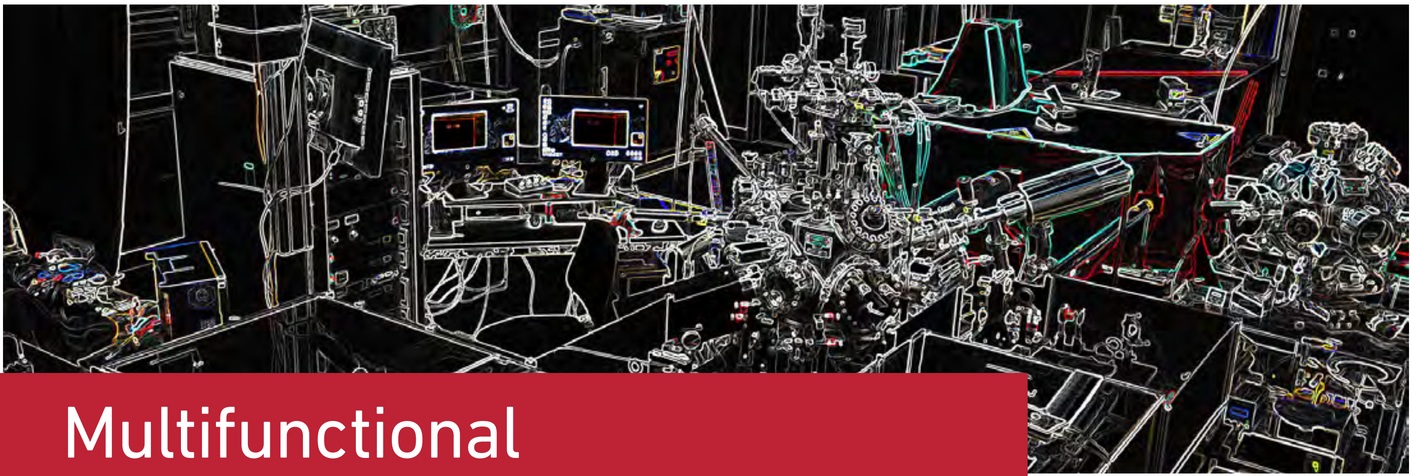

Multifunctional Ferroic Materials

Research Profile

In our group we investigate materials where strong coupling between electrons leads to novel types of ordering of its spins and charges. Our scope is to study the fundamental physics of these materials with an interest in basic research as a foundation for promoting their technological relevance. Our experimental core technology is nonlinear optical spectroscopy in the THz to UV frequency range. It permits us to image ordered states noninvasively and with high spatial and temporal resolution. In addition, we apply sscanning-probe techniques as well as standard magnetic and dielectric characterization methods. Numerical simulations help us to understand the physics behind the various ordering processes. Furthermore, we use pulse-laser deposition (PLD) for growing functional multilayer structures with atomic precision. In a recent device prototype, the PLD growth and nonlinear optics are merged to in-situ probe the emerging ordering of the multilayers during the growth process. Specific material classes of interest are:

- Multiferroics with a coexistence of magnetic and electric order
- Transition-metal-oxides with interface states different from the bulk
- Heavy-fermion materials
- Other correlated materials with phase transitions determined by the competition of spins, charges, lattice, and strain
- Oxide-electronic heterostructures with novel magnetoelectronic functionalities

Competences / Infrastructure

- Pulsed laser systems from 220 nm to 20 µm and 120 fs to 10 ns
- Combined spectrometer-microscope for the range from IR to UV
- Setup for two-dimensional THz time-domain spectroscopy
- Helium-operated cryostats for experiments at 1.7 to 325 K under magnetic fields up to 10 T and electric fields from voltages up to 6 kV
- Scanning probe microscope in a large variety of modes at 1.8 to 300 K
- SQUID magnetometer and ferroelectric tester
- Laboratory for pulsed-laser deposition
- Facilities for bulk sample preparation: cutting, lapping, polishing

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oxides | ultrafast dynamics | multiferroics thin films | simulation | heavy-fermion materials | nonlinear optics

Multifunctional Materials

Research Profile

We conduct both basic and applied research in various areas of materials chemistry, from polymers for corrosion protection to Roman concrete, luminescent particles and composites, multifunctional batteries, heatable fabrics and three-dimensional photocatalysts. At the heart of all our activities is our expertise and enthusiasm for the chemical synthesis of a wide range of functional materials.

The main topics of our research include:

- Development of synthesis strategies to inorganic functional (nano-) materials
- Surface functionalization and processing of (nano-) particles into colloidal dispersions
- Nanoparticle-based aerogels and study of their photocatalytic properties
- Development of photoreactors
- Synthesis of poly(phenylene methylene) derivatives and study of their anticorrosion properties
- Design and fabrication of transparent, degradable and/or stretchable batteries
- Luminescent nanoparticles and study of the optical properties

Competences / Infrastructure

- Liquid-phase synthesis of inorganic materials
- Solvothermal processing and microwave chemistry
- Surface-functionalization, assembly and processing of particles
- Characterization of inorganic materials
- Thin films, aerogels, foams and organic-inorganic nanocomposites
- Battery assembly and testing
- Gas-phase photocatalysis
- Optical characterization of luminescent materials

ETH Zürich
Department of Materials
Multifunctional Materials

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nanoparticles | aerogels | sol-gel synthesis
metal oxides | batteries | photocatalysis

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Multiphase Fluid Dynamics

Research Profile

Our group seeks to better understand various small-scale multiphase fluid phenomena, such as bubble and droplet dynamics. One of our key goals is to control acoustically and optically driven bubble oscillations in order to exploit their energy-focusing qualities in biomedical and engineering applications. We also develop experimental techniques to observe and characterise high-speed multiphase fluid phenomena optically and acoustically. We combine experiments with physical modelling to deliver better explanations and predictions for a wide spectrum of fast and complex fluid flows. The nature of the research is both fundamental and applied.

We focus on the following three research areas:

› Fundamentals of acoustic cavitation, bubble oscillations and phase-change
› Coated and functionalised bubbles and droplets in biomedical imaging and therapy, where they can be non-invasively activated with acoustic waves to interact with bodily tissues
› Engineering applications for impulsive multiphase fluid phenomena, such as sonophoresis, flow processes, ultrasonic sonochemistry, microfluidics, among others

Competences / Infrastructure

› Underwater acoustics
› Cavitation and bubble dynamics modelling
› Complex fluids, colloids, nanoemulsions
› Biomedical acoustics and ultrasound contrast agent microbubbles/nanodrops
› Ultra-high-speed imaging and high-power illumination
› Optical and acoustical flow diagnostics
› Microfluidics
› High-speed videomicroscopy, fluorescence microscopy and X-ray imaging

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Multiphase Fluid Dynamics

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cavitation | bubble dynamics | medical ultrasound
high-speed imaging | experimental fluid dynamics

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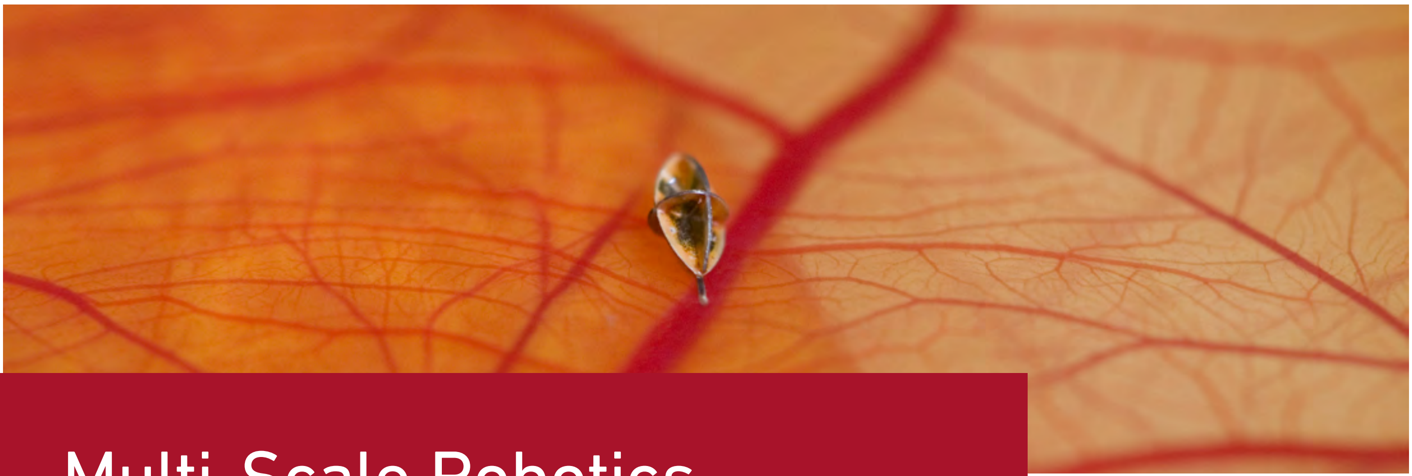

Multi-Scale Robotics

Research Profile

A major component of the Multi-Scale Robotics Lab (MSRL) research leverages advanced robotics for creating intelligent machines that operate at micron and nanometre scales. MSRL develops tools and processes to fabricate and assemble micron sized robots and nanometre scale robotic components. Many of these systems are used for robotic exploration within biomedical and biological domains, such as in the investigation of molecular structures, cellular systems, and complex organism behaviour.

- Microrobotics combines established theory and robotic techniques with tools provided by microelectromechanical systems (MEMS) technology to create intelligent machines that operate at micron scales.
- Nanorobotics includes robots that are nanoscale in size and large robots capable of manipulating objects that have dimensions in the nanoscale range with nanometre resolution. Nanorobotic manipulation is an enabling technology for nanoelectromechanical systems (NEMS) and uses novel nanoscale materials and structures to enable the fabrication of many new nanosensors and nanoactuators.

Topical problems focus on diverse fields such as microrobotically assisted surgery, magnetic actuation and manipulation, micro and nanofabrication, low Reynolds number locomotion, wireless delivery of power, electrostimulation of biological materials, and micro and nanostructure characterization.

Competences / Infrastructure

- Six degrees of freedom manipulation and characterization of micro- and nanometre sized structures
- Electromagnetic manipulation of magnetic microstructures
- MEMS and NEMS
- Microassembly

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microrobotics | nanorobotics
MEMS | magnetics | NEMS

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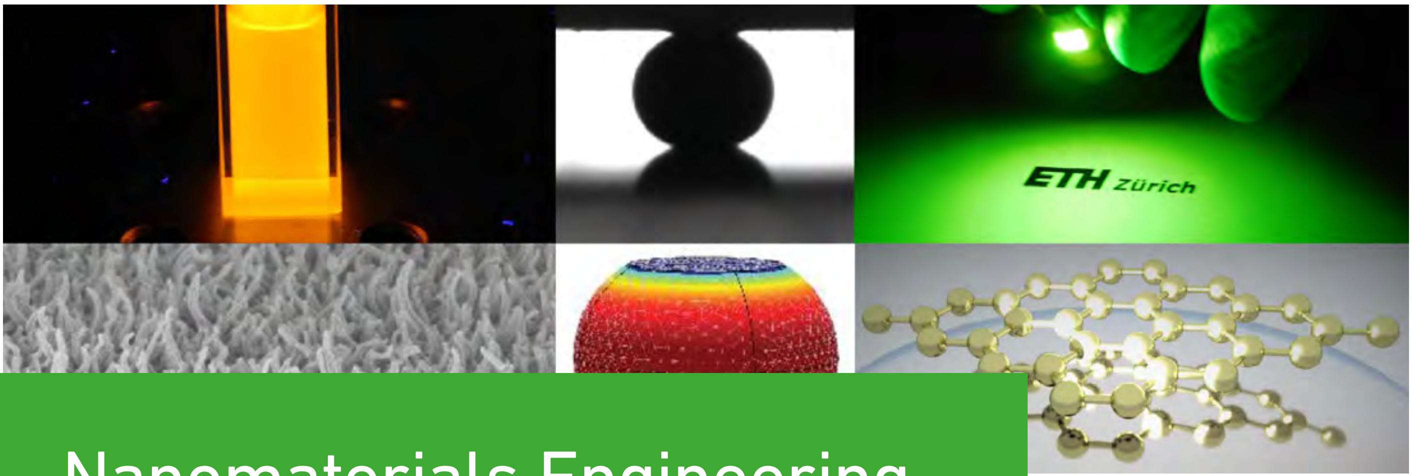

Nanomaterials Engineering

Research Profile

Research in the Nanomaterials Engineering Research Group is focused on understanding the interactions between excitons, electrons, molecules, and reactive species at the interfaces formed between nanomaterials and the surroundings. We are actively engaged in the synthesis of nanomaterials, nanomaterials processing, device fabrication and characterization, as well as mesoscale modelling. We aim to uncover fundamental physics and chemistry at nanomaterials surfaces and interfaces, and utilize the gained insights to develop new engineering strategies that allow us to integrate nanomaterials into existing devices and technologies. With this general goal in mind, our research activities can be summarized as follows: (i) we use mesoscale models and force fields to inform molecular interactions, self-assembly, crystallization, and grain formation at nanomaterials interfaces, (ii) we utilize in-situ microscopy, spectroscopy, optoelectronic characterization, and mathematical modelling to decipher the interplay of physical and chemical forces at the interfaces, (iii) we develop new chemical and physical processes to transfer, sort, and purify nanomaterials, for integrating nanomaterials-based devices into existing technologies, and (iv) we propose, fabricate, and optimize new optoelectronic, sensor, and transistor devices by manipulating the molecular interactions and charge transport at the interfaces.

Competences / Infrastructure

- Multiscale modelling
- Nanomaterials synthesis and processing
- Exciton kinetics and energy transfer
- Light-emitting technology
- Functional transistors
- Sensing and molecular recognition

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interface engineering | optoelectronics
sensors | nanomaterials processing

Nanometallurgy

Research Profile

The Laboratory for Nanometallurgy carries out research in the field of thin films, in which at least one critical dimension is in the nanometre regime and significantly influences the behaviour of materials. These dimensions can be external, where typical applications can be found in microelectronics and micro- and nanoelectromechanical systems (MEMS/NEMS) as well as all coating applications or reflect some important internal length scale like the grain size or the precipitate spacing in alloys. Research topics focused on by this laboratory include the following:

- Mechanical properties of nano- and microcomponents
- Novel nanomechanical testing methods
- Thin film architectures
- Nanostructured 3D materials and systems
- Combinatorial studies of nano- and microalloying effects
- Correlation of mechanical and functional properties

Competences / Infrastructure

- In situ strain measurements and observation of damage evolution (Raman Microscopy, X-ray microdiffraction, Reflectance Anisotropy Spectroscopy, AFM, SEM)
- Nanoindentation and Pillar compression as a function of temperature
- Combinatorial thin film synthesis (Magnetron sputtering, electrodeposition)
- Microstructure engineering by ion bombardment
- 3D nanostructure formation
- Imaging capabilities (Confocal Raman Microscopy, TEM, AFM)

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Nanometallurgy

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metals | mechanical properties | thin films
microstructure control | functional properties
nanostructures | semiconductors and oxides

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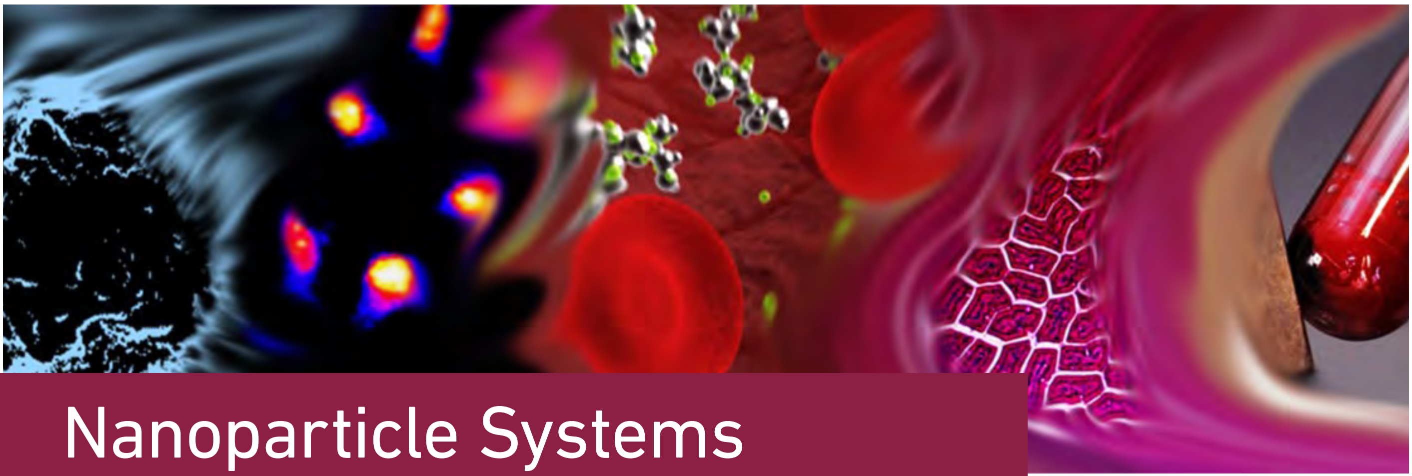

Nanoparticle Systems Engineering

Research Profile

The Nanoparticle Systems Engineering Lab is focused on the design and development of nanotechnology-enabled solutions addressing various clinical needs. By deploying engineering principles clinical problems are tackled by integrating nanoparticle engineering, machine-learning-assisted analytical multiscale imaging and translational nanomedicine.

The activities of the NSE lab are centred around three main activities:

- Improving the understanding of health and disease based on advanced analytics
- Development of next generation particle-based diagnostics and therapeutics
- Multiscale multimodal analysis of the interface between engineered and natural systems

The overarching goal is to combine experimental and modelling approaches for a holistic understanding of the interplay of materials with biology across various scales resulting in rational adjustments of materials design.

Competences / Infrastructure

- Nanomaterial design and synthesis
- Multiscale analytical imaging
- Preclinical and translational models (in vitro, in vivo, ex vivo)
- Advanced materials characterization techniques (XRD, SAXS, CT)
- Raman and FTIR spectroscopy
- Electron microscopy (SEM/EDX/CL, STEM, TEM, FIB/SEM)

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Nanoparticle Systems Engineering

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chemical engineering | particle synthesis bioimaging | translational research personalized health | surface engineering

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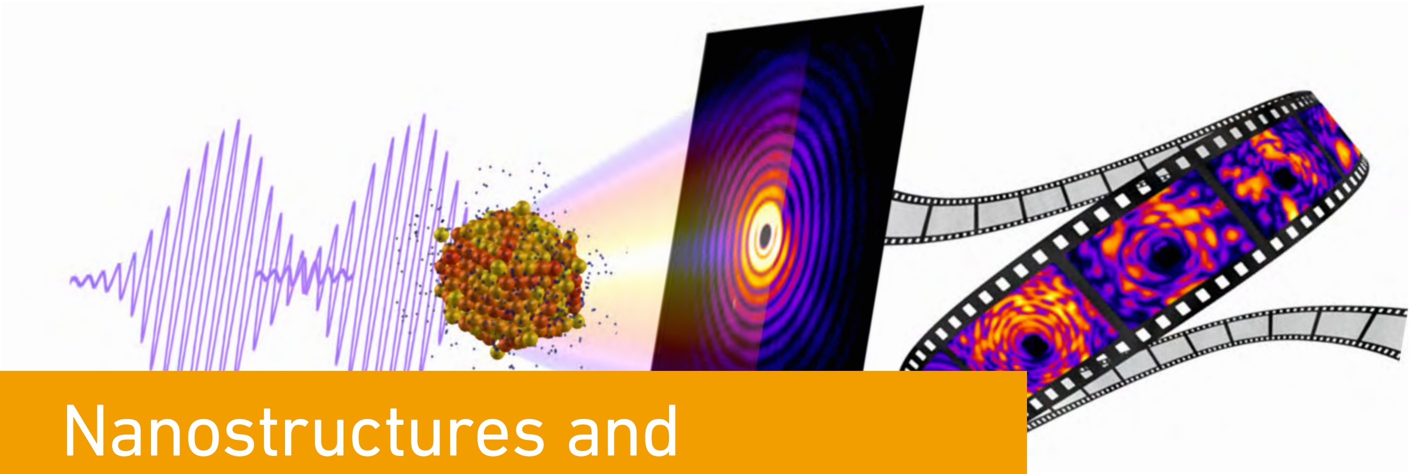

Nanostructures and Ultrafast X-Ray Science

Research Profile

Our group investigates the formation and ultrafast dynamics of nanoscale structures. Intense X-ray pulses allow us to gain a high-resolution insight in both time and space and develop a better understanding of intense light-matter interaction.
Key to such investigations are sufficiently intense and ultrashort short-wavelength pulses, realised through X-ray free-electron lasers (XFEL) and high-harmonic sources (HHG). Coherent diffractive imaging (CDI) is used as a unique method to study growth and assembly of atoms to nanostructures under extreme conditions. Combined with ion and electron spectroscopy, the single-particle CDI experiments provide unprecedented insight into light-induced dynamics in matter. The ultrashort pulses from HHG sources hold the promise to map excitation and charge separation processes in nanoscale matter on their natural time scale. Using extreme ultraviolet (XUV) wavelengths trades spatial resolution for 3D information about the shape and orientation of individual nanoscale specimen allowing the in-situ study of e.g. nanocrystal or aerosol formation with relevance for e.g. material science, chemistry or astrophysics. To evaluate the vast amount of experimental data generated, the group utilizes deep neural networks for image classification and analysis.

Competences / Infrastructure

- Extreme ultraviolet (XUV) & X-ray free-electron lasers (XFEL)
- Coherent diffractive imaging (CDI)
- High-harmonic-generation (HHG)
- High-intensity HHG Beamline
- Helium droplet source (Helium flow cryostat)
- Source for atomic clusters (pulsed supersonic nozzle expansion)
- Simulations & machine learning

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Nanostructures and Ultrafast X-Ray Science

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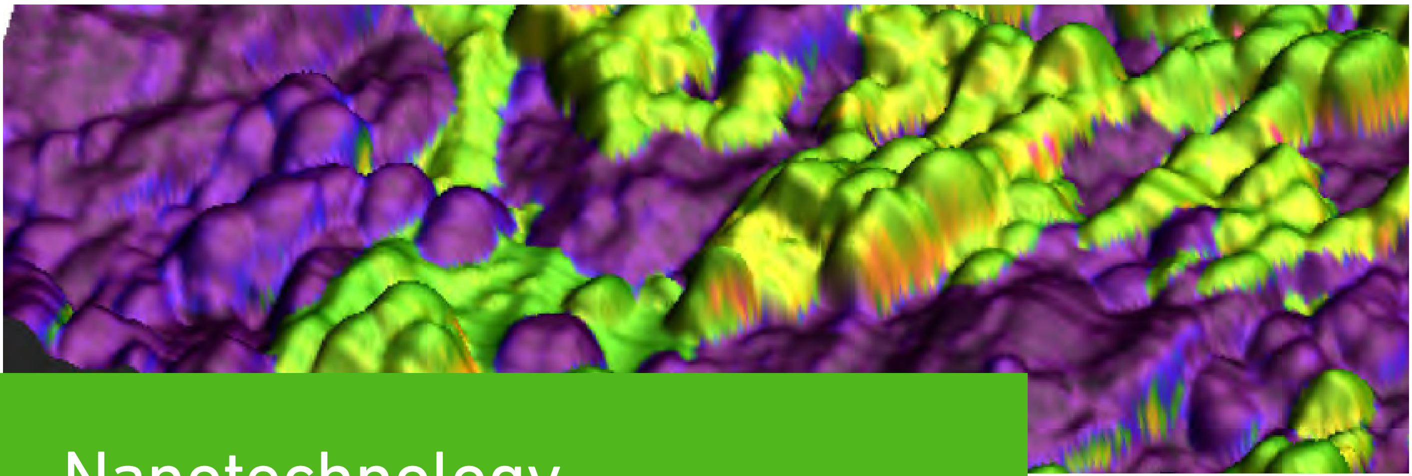
nanostructures | ultrafast | intense X-rays
neural networks | diffraction imaging



Nanotechnology

Research Profile

Research in several areas of nanoscale science and technology, with a special focus on:

- Nanoscale and molecular electronics employing individual molecules or their assemblies as functional electronic building blocks. Designable functionality and precise composition of molecules, coupled with their small size, make this concept a potential candidate to overcome the increasing difficulties current CMOS technology faces upon further downscaling to reach higher performance. Furthermore, in energy research, molecular components and nanometre sized solid materials link concepts from quantum mechanics with real-world applications.
- Development of advanced scanning probe microscopy techniques to map charge and potential distributions, temperature, luminescence, and further material contrasts on the nanometre scale to quantify parameters having a crucial influence on the performance of nanoscale electronic devices.
- Bottom-up strategies for directed assembling and electrically interfacing functional nanoscale components and molecules into device structures, as well as local probing of structure and function at high spatial resolution.

Competences / Infrastructure

- Atomic Force Microscopy (AFM): multi-frequency AFM and custom-made setups with alternative force sensors
- Kelvin Probe Force Microscopy (KFM) for spatially resolved measurements of the electrostatic surface potential
- Photo-induced force microscopy

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molecular electronics | advanced microscopy
patterning and directed assembly

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Nonlinear Optics for Epitaxial Growth of Advanced Thin Films (NEAT)

Research Profile

Our group focuses on complex oxide thin film growth and investigates interface phenomena as well as functional properties in epitaxial ferroelectric and multiferroic thin films and heterostructures. Our research involves the thin film growth by pulsed laser deposition and sputtering and the advanced characterization of their ferroic domain structures using a wide range of scanning probe microscopy. We are pioneering the investigation of thin films functionalities in-situ, during the epitaxial synthesis, using an unprecedented combination of experimental techniques. In-situ electron diffraction and optical second harmonic generation experiments allow for real time structural and functional characterization with sub-unit cell accuracy directly during the deposition process. We scrutinize the complex interplay of epitaxial strain, lattice chemistry and electrostatic environment on the ferroelectric properties of our films in order to identify routes for the integration of functional thin films into energy efficient electronics.

Competences / Infrastructure

› RHEED assisted pulsed laser deposition
› Scanning probe microscopy (PFM, MFM, AFM, C-AFM)
› SHG assisted pulsed laser deposition
› In situ optical second harmonic generation
› Operando characterization of ferroelectric switching events
› Real time monitoring of functional thin film epitaxial design

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NEAT Lab

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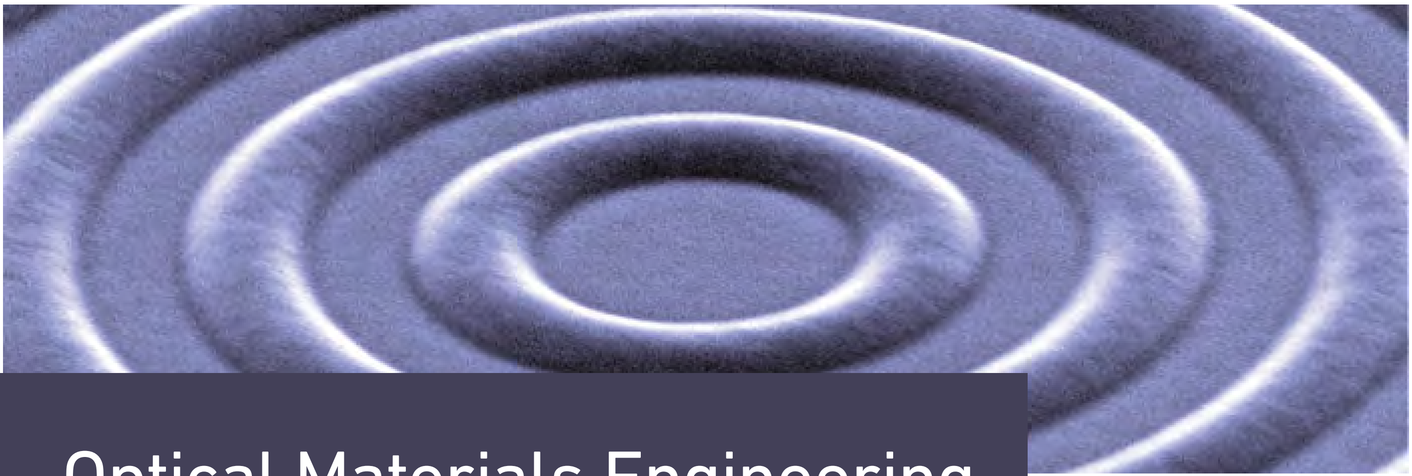
oxide epitaxy | PLD | in-situ SHG ferroelectrics | multiferroics | thin films



Optical Materials Engineering

Research Profile

Nanotechnology provides the ability to shape and pattern matter in amazing ways. The goal of the Optical Materials Engineering Laboratory (OMEL) is to utilize this ability to create materials that have interesting and advantageous interactions with light. By tailoring the size, shape, or periodicity of a solid, one can alter its optical behaviour. Moreover, if one is clever, one can create properties not observed in any natural material.

In OMEL, we aim to fabricate such structures and investigate the new phenomena that result. While we sometimes employ the sophisticated processes developed by the semiconductor industry to shape our materials, we also seek much simpler strategies, e.g., based on colloidal chemistry or self-assembly. Within our broad goals, current efforts within OMEL are focused on two specific classes of optical materials:

- Nanoscale semiconductor particles (known as nanocrystals or quantum dots) to investigate the influence of size
- Thin patterned films (known as photonic or plasmonic surfaces) to investigate shape. In addition to studying fundamental properties of these materials, we are exploring their use to improve optical devices, from solar cells to new types of lasers. Because we fabricate and characterize all of our own structures and devices, researchers within OMEL become highly proficient in a broad range of skills.

Competences / Infrastructure

- Chemical synthesis of colloidal semiconductor nanocrystals
- Fabrication of photonic and plasmonic structures
- Optical spectroscopy
- Optoelectronic devices
- Electron microscopy

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Optical Materials Engineering

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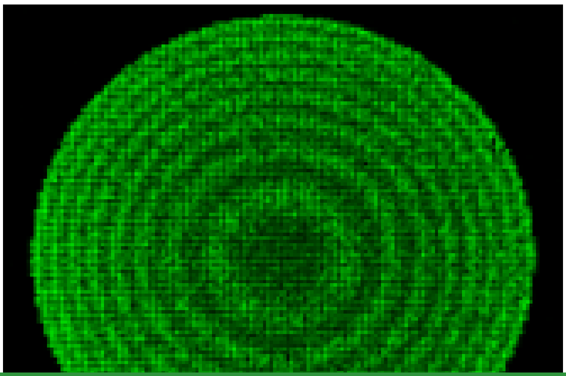
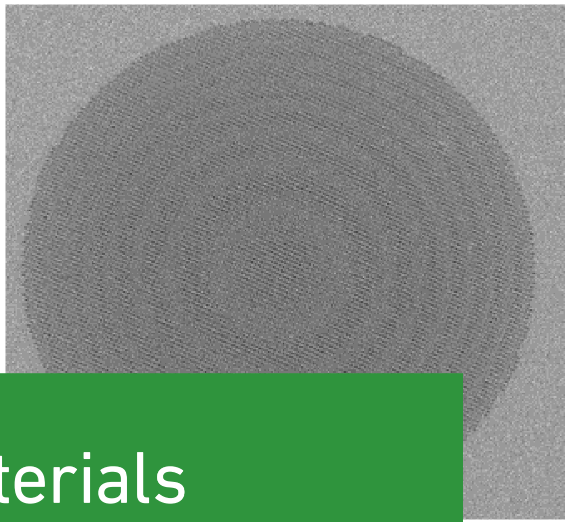
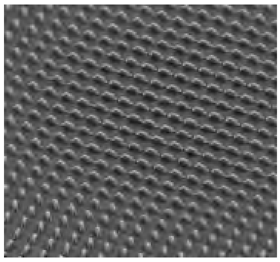
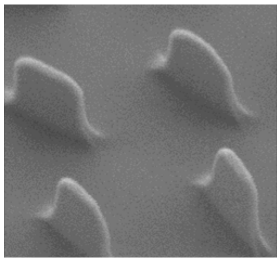
photonics | optical materials
quantum dots | plasmonics









Optical Nanomaterials

Research Profile

The Optical Nanomaterial Laboratory investigates fundamental aspects of nonlinear materials from single to complex systems. The team of Rachel Grange aims at engineering multifunctional unconventional material for miniaturized classical or quantum devices. Indeed, this field is dominated by metals and semiconductors for their reliable optoelectronic properties. In contrast, her laboratory focuses on a new family of nanocrystals, metal-oxides such as lithium niobate or barium titanate, with additional optical properties. The main goal is to find strategies to enhance optical responses at the nanoscale and to achieve easy fabrication to supply the demand of telecommunication industry (fast and small modulator), of sensing in harsh environment (light and solid spectrometer for space, flat lenses with large surface area), or of future computers (integration of quantum components on chip).

Competences / Infrastructure

- Nonlinear photonics
- Integrated optics
- Oxides and semiconductors nanomaterials
- Non scanning multiphoton microscopy
- Solution processed photonic structure
- Metasurface
- Nanofabrication
- Nanoimprint lithography
- Focus ion beam processing
- Lithium niobate and barium titanate
- Nonlinear complex media

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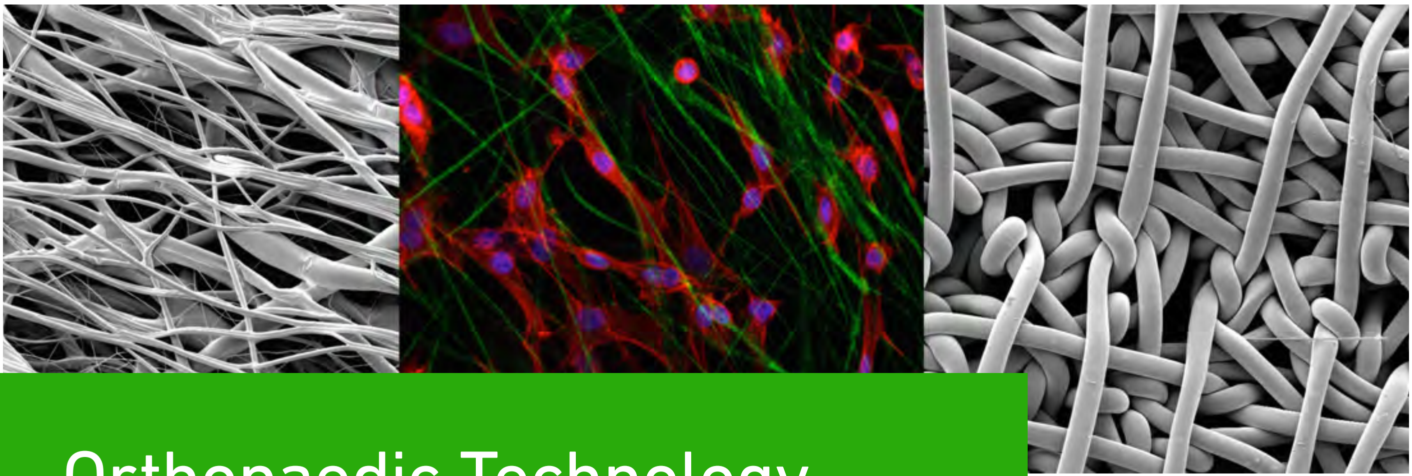
nonlinear optics | multipolar microscopy integrated photonics | nanoparticles | quantum photonics | complex media | random networks



Orthopaedic Technology

Research Profile

We are an interdisciplinary research group developing new technologies to understand the causes of musculoskeletal diseases and to work towards new treatments. Our research combines basic orthopaedic sciences, biology and engineering, with a strong translational component to transform research findings into clinical applications.

One focus is the development of inert or bioactive injectable biomaterials for the treatment of bone fragility, addressing both osteoporotic fracture fixation and prophylactic applications to prevent fracture. An outgrowth of this research has been the optimisation of such cements to allow their use in more complex and mechanically challenging trauma applications, applying principals from the civil engineering domain to achieve the desired toughness.

Our group has developed nano and microfibrous membranes and lattice structures as scaffolds for the treatment of soft-tissue pathologies, such as intervertebral disc degeneration, labrum tears and cartilage erosion. Simulation models are used extensively to inform the design of these multi-layer structures, achieved through methods such as stitching, electrospinning, melt electrowriting or extrusion. We aim to further functionalise these injectable and fibrous biomaterials through incorporation of specific agents to combat inflammation, promote new tissue growth and reduce friction for articulating tissues.

Competences / Infrastructure

- Electrospinning and melt electrowriting
- Textiles
- Ceramic and polymer cements
- Injection mechanics and rheology
- Resorbable polymers
- Inflammation control and drug delivery
- Tissue mechanics
- Mechanical testing
- MicroCT
- Finite element analysis

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tissue engineering | electrospinning | hydrogels
melt electrowriting | injectable cements

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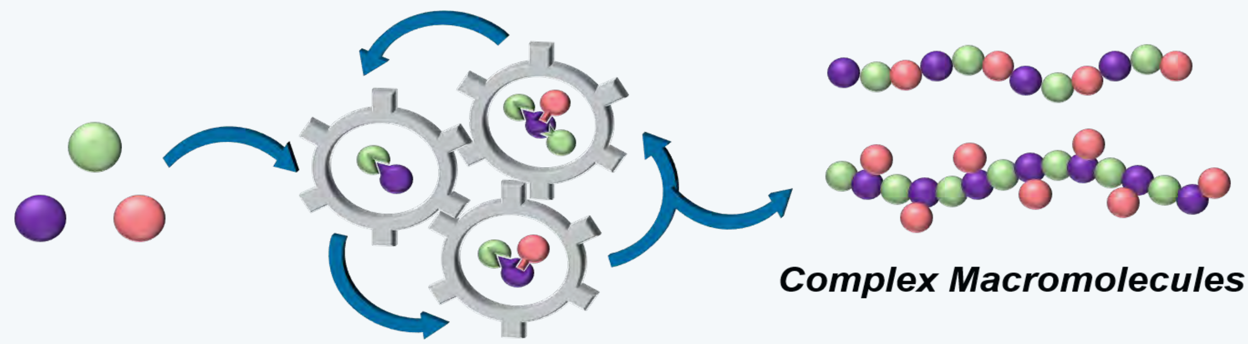

Polymer Chemistry

Research Profile

Interests of the Polymer Chemistry lab are heavily focused on chemical synthesis from small to macromolecules. With the powerful tool of modern synthesis in hand, one can make various molecules not only with high molecular weights, but also with high specificity and selectivity. By doing so, we can manipulate their structures, functionalities and ultimately properties. Following are the list areas of our research directions.

- Novel new living polymerisations by understanding the catalysis, especially using transition-metals complexes which can bring new reactivity and selectivity.
- Novel self-assembly strategies such as in-situ nanoparticlisation of conjugated polymers which spontaneously and efficiently produces nanostructures without any post-modification.
- Crystallisation-driven self-assembly of conjugated polymers to produce semi-conducting nanostructures with excellent controls.
- Synthesis of conjugated polymers which are very attractive materials having a high potential as future electronic devices
- Mechano-chemistry on polymers to study their degradation or even depolymerisation.

Competences / Infrastructure

- Chemical Synthesis
- NMR (structural analysis)
- SEC (molecular weight information)
- Mass-spectrometry
- TEM (imaging tool)

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polymer synthesis | living polymerization catalysis | conjugated polymer | self-assembly

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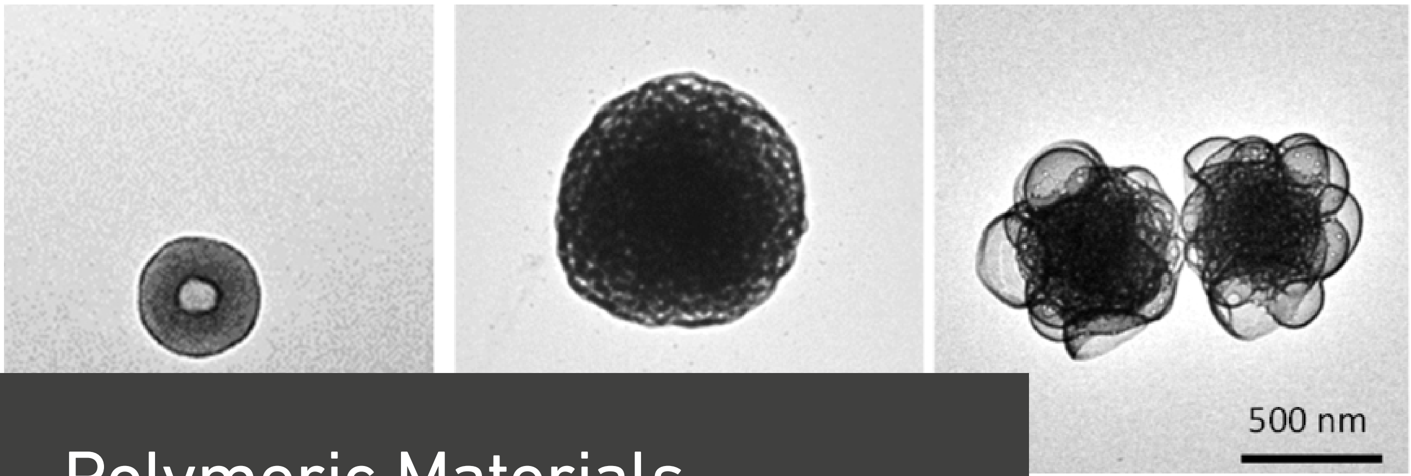

Polymeric Materials

Research Profile

The Polymeric Materials Group focuses on the development of new methods for the synthesis of smart polymers and polymeric nanomaterials. Controlled radical polymerization strategies are routinely exploited to produce polymeric materials with controlled architecture, molecular weight, dispersity and functionality. A special focus is given to improving existing methodologies, understanding underlying polymerization mechanisms, and translating the knowledge acquired. Subsequently, the self-assembly of polymeric materials into nanostructures is assessed in detail to understand and control all their physicochemical properties (e.g. size, shape, surface, core). The key to the group's strategy is the aim to understand the fundamentals of polymerization mechanisms and allow facile access to the production of well-defined polymeric (nano)materials. Upon synthesis and/or self-assembly a wide range of applications in the material and biomedical field can be targeted.

Competences / Infrastructure

- NMR (polymers, organic molecules and structure)
- TEM (morphology of polymers)
- GPC (molecular weight and dispersity)
- Mass-spectrometry (end-groups)
- Dynamic light scattering (particle size)

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polymers | controlled radical polymerization sequence-control | polymeric micelles synthesis | self-assembly | nanomaterials

MaP Competence Center for Materials and Processes

Production and Operations Management

Research Profile

The Chair of Production and Operations Management (POM) is concerned with the productivity of technology, people, and processes. POM is at the heart of any business and covers processes that transform inputs into outputs and deliver products and services to customers. The Chair of POM conducts empirical and innovative research that creates better operations for industry and society.

The use of new technologies, such as digitization, artificial intelligence, additive manufacturing and robotics in production, behavioural operations and strategic issues such as production footprint strategy are all highly relevant. Research is carried out in cooperation with leading companies and various academic partners. The Chair of POM has the following main research foci:

- Smart Manufacturing
- Operational Excellence
- Global Production
- Behavioural Operations

Competences / Infrastructure

- Industrial engineering
- Manufacturing management
- Data-driven productivity improvement
- Digital transformation strategies
- Tailored production improvement programs
- Lean production / operational excellence
- Manufacturing network configuration

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Chair of Production and Operations Management (POM)

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productivity | industrial engineering
operational capability | new technologies

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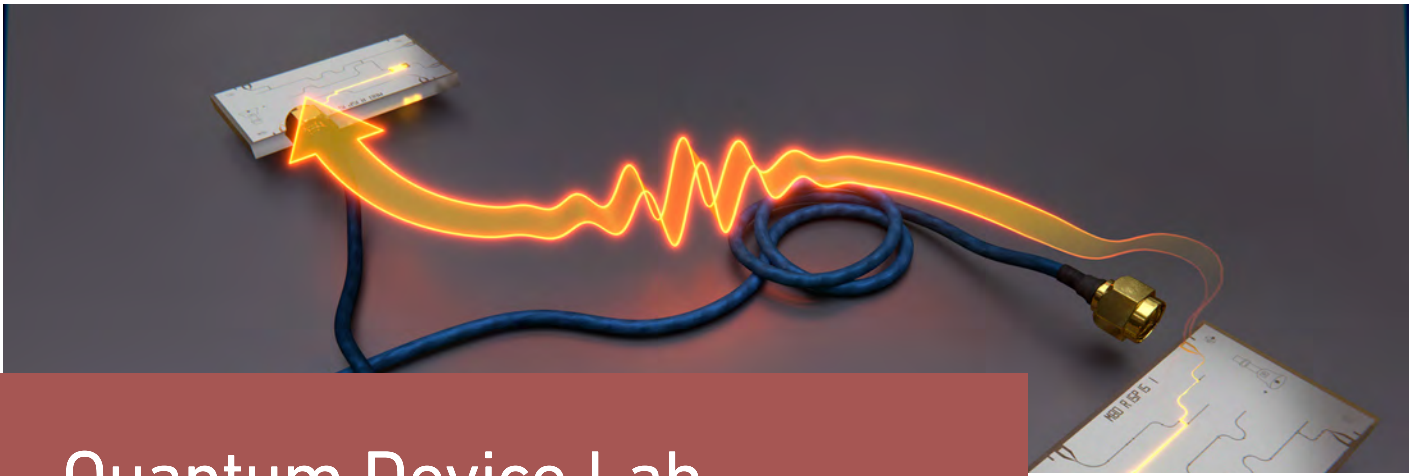

Quantum Device Lab

Research Profile

In our lab we pursue research at the intersection of the fields of solid state physics, atomic physics and quantum optics covering areas such as:

- Quantum information processing and simulation with superconducting electronic circuits. We design, realize and test micro- and nano-scale electronic circuits operating based on the laws of quantum physics to explore new paradigms for efficient information processing and simulation.
- Circuit quantum electrodynamics (QED). We study the creation, interaction and detection of individual microwave photons in electronic circuits for fundamental quantum optics experiments and also for applications as radiation sources and detectors.
- Low loss materials. We perform research on high quality materials for high frequency electronic circuits.
- Hybrid quantum systems. Exploration of devices combing semiconducting and superconducting structures also integrated in atomic physics settings.

Competences / Infrastructure

- Design and fabrication of integrated quantum electronic circuits
- Development and realization of microwave frequency electronics
- Characterization and operation of electronics at ultra-low temperatures
- Realization of high bandwidth data acquisition and analysis systems also based on field programmable gate arrays (FPGA)
- Development of cryogenic systems

ETH Zürich
Department of Physics
Quantum Device Lab

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The Quantum Device Lab is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

molecular electronics | quantum computing | superconducting electronics low loss materials | cavity QED

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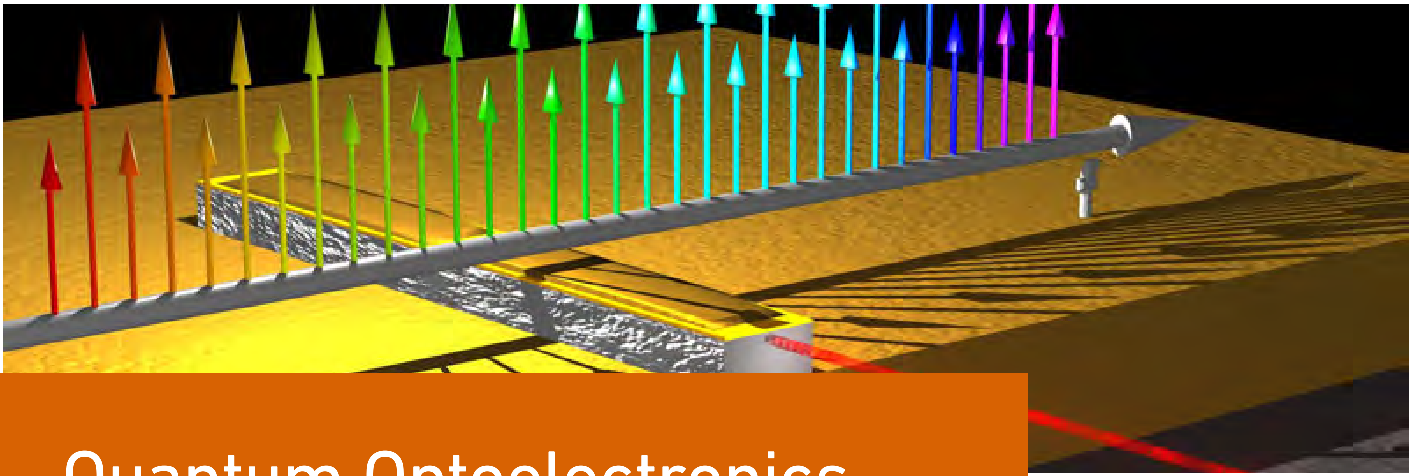

Quantum Optoelectronics

Research Profile

By combining confinement inside heterostructures with optical confinement at the micro and nanoscale, new devices are created where electron and photons flows are engineered. Our lab emphasizes the use of these techniques to unlock the scientific and technological potential of the mid-infrared and Terahertz spectrum of the electromagnetic radiation.

One area of research concerns the Quantum Cascade Laser (QCL) and its application for generating Terahertz, frequency agile devices as well as optical frequency combs. The group also focuses on the use of metamaterials and the physics of the ultra-strong light-matter coupling and the general goal of developing Terahertz quantum optics.

Competences / Infrastructure

- III-V waveguide and device epitaxy and processing
- Metamaterials design and fabrication
- Mid-infrared spectroscopy and laser spectroscopy
- Terahertz time-domain spectroscopy (THz-TDS)
- Magneto-spectroscopy in the THz
- Transport measurements at Kelvin to milli-Kelvin temperatures

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Department of Physics
Quantum Optoelectronics

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The Quantum Optoelectronics Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

quantum cascade lasers for spectroscopy
frequency combs | THz lasers and technology
metamaterials and ultra-strong coupling

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Renewable Energy Carriers

Research Profile

The Professorship of Renewable Energy Carriers (PREC) is committed to excellence in research and education. It performs pioneering R&D projects in solar energy engineering, operates state-of-the-art experimental laboratories, offers advanced courses in fundamental/applied thermal sciences, and contributes to the education of scientists and engineers with expertise in clean energy technologies.

PREC's research program is aimed at the advancement of the thermal and chemical engineering sciences applied to renewable energy conversion. The fundamental research focusses on high-temperature heat/mass transfer phenomena, multi-phase reacting flows, thermochemistry and functional redox materials. These are applied in the development of technologies for concentrated solar power and solar fuels production, solar-driven thermochemical processing of energy-intensive chemical commodities, direct air capture of CO2 and its utilization, energy storage and sustainable energy systems. PREC pioneers the development of solar concentrating technologies for efficiently producing clean power, fuels, and materials.

Competences / Infrastructure

- Engineering design, fabrication, testing, optimization, and scale-up of efficient thermal converters and chemical reactors
- Thermodynamic and kinetic analyses
- Heat and mass transfer computational modelling
- High-temperature materials development
- High-flux solar optics and spectroscopic goniometry
- Solar concentrating research facilities for high-flux (>5,000 suns) and high-temperature (>1000°C) applications

ETH Zürich
Department of Mechanical and Process Engineering
Renewable Energy Carriers

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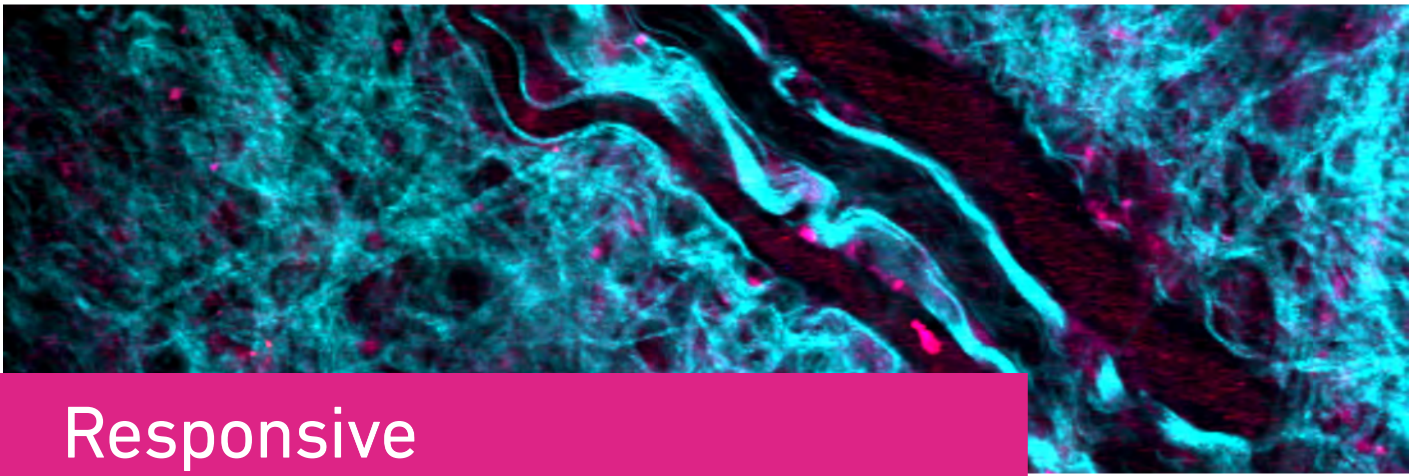
solar power | solar fuels | heat transfer
thermal storage | thermochemistry
solar materials | H_2O and CO_2 splitting
CO_2 capture | renewable energy technologies



Responsive Biomedical Systems

Research Profile

Residing in the Institute for Translational Medicine of D-HEST, Prof. Schürle-Finke and her team aim to tackle a range of challenging problems in health care by engineering micro- and nanoscale systems. In particular, the group develops systems that produce a diagnostic or therapeutic output in response to local signals inherent to the disease environment, such as characteristic pH levels or enzymatic activity, or in response to externally applied signals including acoustic and magnetic stimuli. Prof. Schürle-Finke envisions strategies for applying such responsive systems to the diagnosis and treatment of diseases ranging from cancer to fatty liver disease.

Engineering responsive micro- and nanoscale systems entails chemical synthesis, nanofabrication, and numerical modelling. The work is inherently interdisciplinary and relies on the convergence of several fields, integrating methodology and ideas from chemists, physicists, engineers, and mathematicians. In addition to devising systems that detect or treat disease, the group also investigates disease mechanisms in vitro at the cellular level, making extensive use of magnetic micromanipulation and microfluidic models.

Competences / Infrastructure

- Nanosystems synthesis and functionalization
- Nanomaterial characterization
- Magnetic micromanipulation
- Microfluidic device fabrication
- Numerical modelling
- Magnetotactic Bacteria
- Lab-On-A-Chip

ETH Zürich
Department of Health Sciences and Technology
Responsive Biomedical Systems

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The Responsive Biomedical Systems Lab is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

responsiveness | modelling | nanotechnology
engineering | functionalization | microfluidics

Robotic Systems

Research Profile

The Robotic Systems Lab develops machines and their intelligence to operate autonomously in rough and challenging environments. With a large focus on robots with arms and legs (e.g. quadrupedal robots, mobile manipulators, hybrid wheel-leg systems), the research includes novel actuation methods for advanced dynamic interaction, innovative designs for increased system mobility and versatility, and new control and optimization algorithms (including deep and reinforcement learning) for locomotion and manipulation. In search of clever solutions, we take inspiration from humans and animals with the goal to improve the skills and autonomy of complex robotic systems. Our machines are deployed in various real-world scenarios, such as for exploration and inspection of offshore industrial sites, mines, sewer, tunnels, or caves, for search and rescue operations, in rehabilitation and for construction.

Competences / Infrastructure

- Indoor and outdoor robotics lab
- Various robotic systems including legged robots, mobile manipulators, rehabilitation robots, and autonomous construction machines
- Two national competence centres (NCCR robotics and NCCR digital fabrication)
- Software infrastructure for machine learning and optimal control
- Electric and hydraulic actuator test bench setups

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Robotic Systems

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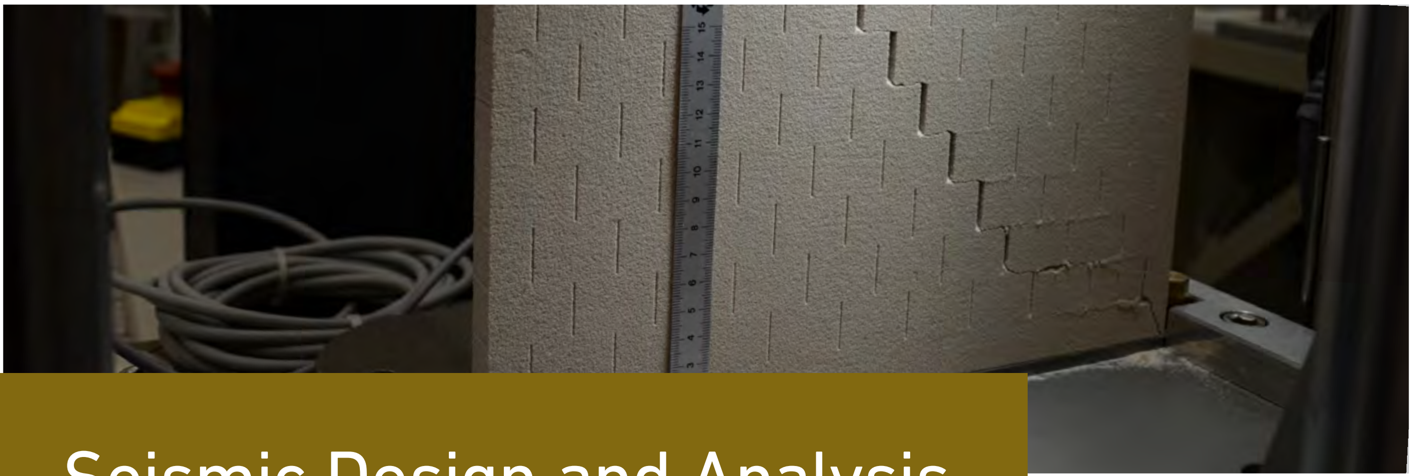
robotics | machine learning control
mobile | manipulation | actuation
quadruped | digital fabrication



Seismic Design and Analysis

Research Profile

We perform research in Earthquake Engineering trying to answer the following questions:

- How can we construct structures that would sustain only minimal damage during an earthquake?
- How can we reduce the cost of earthquake resistant structures by developing new design concepts and devices?
- How safe are existing structures? Is it worth upgrading them? How?
- Should we refine our structural models or does the excitation uncertainty prevail?
- Can we re-solve the Seismic Design problem in the socio-economic context of the low income countries? With what kind of materials?

To this end, we work along the following research lines:

- Seismic design of precast structures with dry connections to ensure resilience and to promote design for re-use
- Seismic Behavior of equipment and non structural components
- Seismic isolation with a particular emphasis on methods for low-income countries
- Innovative structural testing methods using Additive Manufacturing Technologies

Competences / Infrastructure

- Voxeljet VX500 3D printer (binder jet, sand-based)
- Multiple structural testing setups in the IBK lab
- Numerical Modelling of the seismic response of structures and equipment

ETH Zürich
Department of Civil, Environmental and Geomatic Engineering
Seismic Design and Analysis

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earthquake engineering | seismic isolation
structural testing | additive manufacturing

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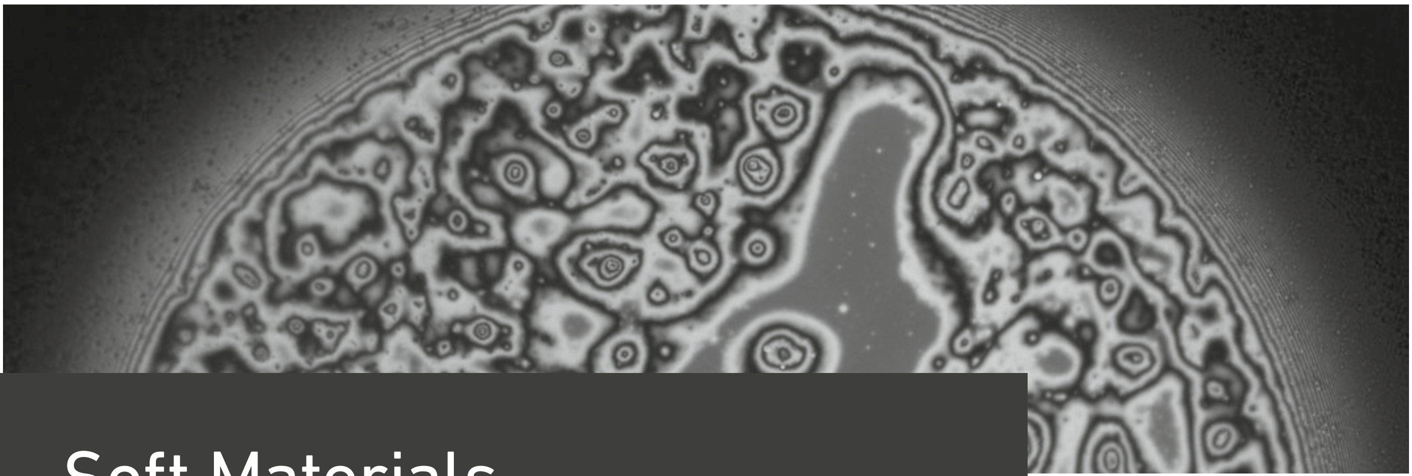

Soft Materials

Research Profile

The Soft Materials Group investigates the fundamentals and engineering challenges with soft materials. The latter embrace a wide variety of materials, ranging from colloids to polymers and surface-active materials. The triangle rheology-structure-properties plays a central role. We combine methods that investigate properties with in-situ and time-resolved measurements of the microstructure, in 2D and 3D systems. To do so, we develop our own instruments and techniques.

Concerning fundamentals there is a strong focus on understanding the rheology and thermodynamics of interfaces and bilayer systems. We then use these insights to design materials and novel fractal processing techniques, which are designed for structuring such multiphase materials. Gel materials constitute another area of interest, either as colloidal thixotropic materials or as polymeric intermediaries towards high performance materials. Understanding structure-property-processing relations is another central theme in our research, with sustainability taking on an increasingly important role.

Competences / Infrastructure

- Advanced rheometric methods
- Thermal analysis (DSC, DMA, TGA), GPC, analytical characterization techniques
- Light scattering (static, dynamic)
- Ultra-high-speed confocal microscopy (4D imaging)
- Fluorescence microscopy (upright and inverted) with high speed camera
- Acoustic and magnetic tweezers
- Langmuir troughs, interfacial rheometry in shear and dilation
- Dynamic thin film balance
- Polymer and colloid processing equipment, mixing flows
- Microfluidic environments for testing of complex fluids and complex interfaces

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Department of Materials
Soft Materials

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soft matter | colloids | polymers
rheology | surface active materials

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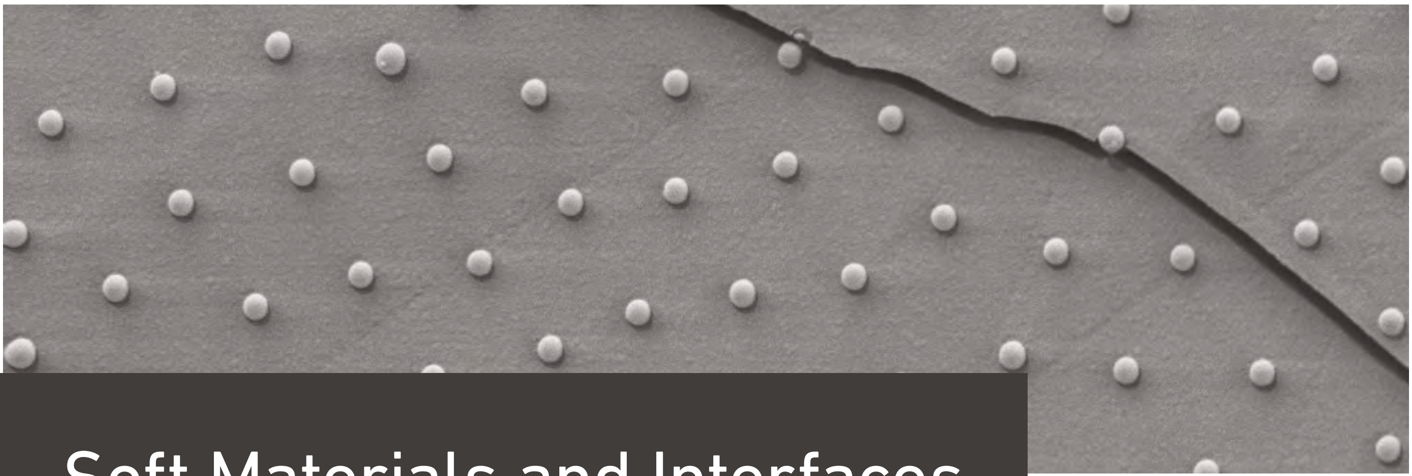

Soft Materials and Interfaces

Research Profile

We strive to understand and engineer the basic physical and chemical properties of micro and nanoparticles, or colloids, and of complex fluid interfaces to develop new materials and processes. Our research encompasses the development of new characterization techniques and the development of model systems at the microscale, which we can interrogate to control macroscale properties. We have recently focused on three main properties: roughness (1), softness (2) and asymmetry (3).

- Surface roughness (1) affects a broad range of different phenomena, where interparticle contacts are essential. We have produced "raspberry-like" particles with tunable surface chemistry and topography and demonstrated the production of new types of emulsion stabilizers or the tailoring of the shear-thickening response of dense pastes.
- By controlling the softness (2) of the interactions between colloids confined at a fluid interface, we disclose new routes for the realization of complex two-dimensional materials, with potential for surface patterning and nanolithography.
- Compositional and geometrical asymmetry (3) is at the basis of micro and nanoscale active materials. By exploiting nanopatterning and capillary forces, we produce asymmetric active colloids that can convert external energy sources into directed propulsion, enabling a broad range of applications in delivery, transport and control at the microscale

Competences / Infrastructure

- Active materials
- Particle self-assembly and colloidal lithography
- Wetting through cryo-electron microscopy
- Friction and rheology of colloidal materials
- Combined atomic force and fluorescence microscopy
- Quantitative optical, atomic force and electron microscopy
- Particle tracking and flow visualization

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Soft Materials and Interfaces

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fluid interfaces | soft matter
colloids | active materials

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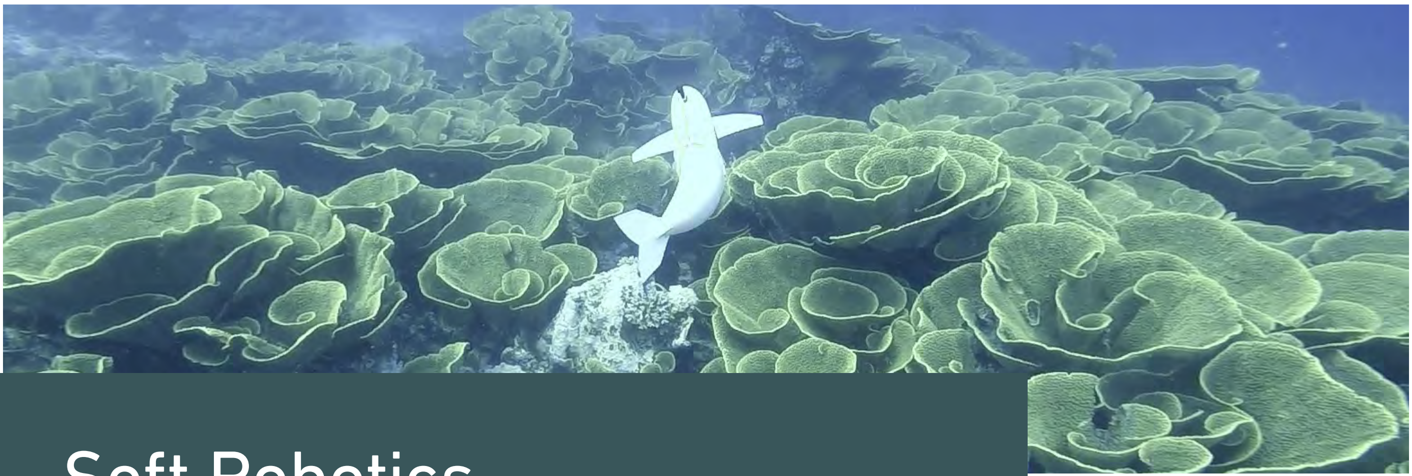

Soft Robotics

Research Profile

The lab`s goal is to build, model, and control robots in a fundamentally different way, so that they become more flexible, dexterous, capable, and adapt better to their environment. We essentially develop so-called soft robots and biohybrid robots, made from compliant materials similar to those found in living organisms. We design and fabricate fluidic and electric drive concepts and develop modelling, controls, and machine learning algorithms to enable soft, flexible, and adaptive interactions of robots with objects and living beings.

The lab showcases its research in both design and algorithms through several real-world applications including a soft robotic fish for underwater exploration, soft robotic hands for pick-and-place tasks, and multi-segment arms for dynamic object manipulation.

Competences / Infrastructure

- Soft Robotics
- Controls
- Modelling
- Mechanical Design
- Soft Robotic Fabrication
- Biohybrid Robotics
- Machine Learning

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Soft Robotics

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design | control | mechanical modelling
experiments | fabrication | soft robotics
machine learning | bioinspired robotics

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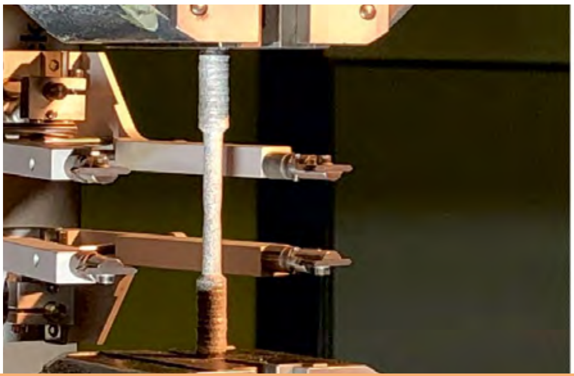
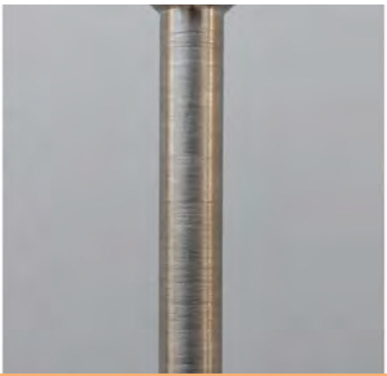
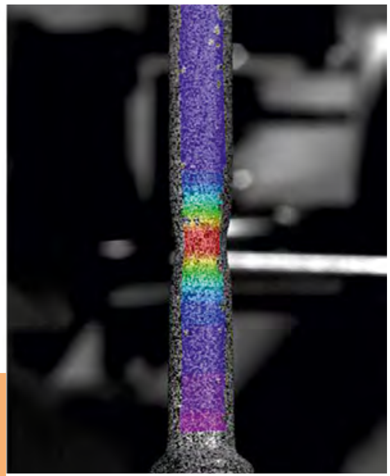

Steel and Composite Structures

Research Profile

We aim to facilitate and improve the design, construction and protection of sustainable, resource-saving and aesthetically appealing buildings, bridges and other types of infrastructure, including large-diameter metallic tanks and pipelines. To this end, we deal with load-bearing structures made of steel, steel-concrete-composite and light metal alloys. To advance the digital transformation in structural engineering, we develop modern, simulation-based design and verification procedures with the help of large-scale experimental, numerical and probabilistic methods.

Research focuses:

› Novel design & assessment methods
› Innovative fabrication, assembly & test methods
› Advanced & resilient structural solutions
› Glass, facade & lightweight structures

Competences / Infrastructure

› Load-bearing capacity of steel, composite and aluminium components under static, dynamic and impact-like actions
› Residual load-bearing capacity of structural elements at the end of their scheduled service life due to fatigue, ageing or unplanned damage
› Development and improvement of protective devices, against extraordinary load cases, e.g. in seismic scenarios
› Advanced analytical & numerical simulation tools – "design by analysis"
› Data-driven methods for structural performance prediction
› Applications of advanced and additive manufacturing

ETH Zürich
Department of Civil, Environmental and Geomatic Engineering
Steel and Composite Structures

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constructional steelwork | structural engineering steel-concrete composite structures | design by analysis | process-based structural performance

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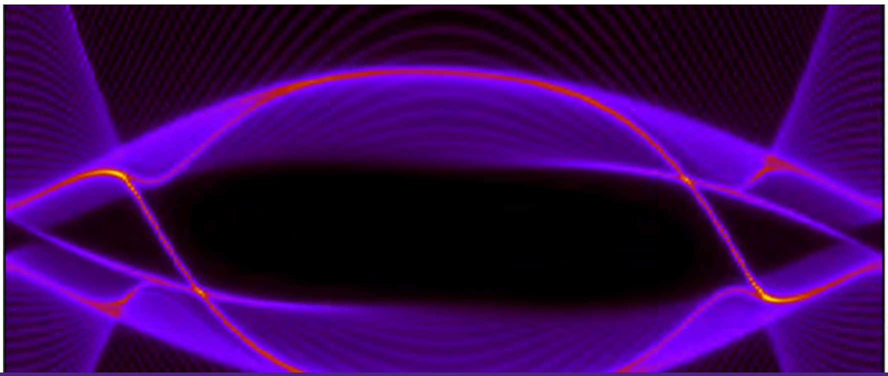

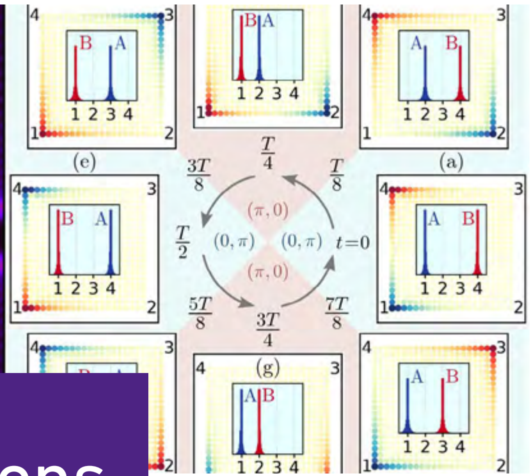

Strongly Correlated Electrons

Research Profile

Our research field is materials-oriented theoretical condensed matter physics with special focus on:

- unconventional superconductivity in heavy Fermion compounds, cuprates, ruthenates, pnictides & artificially structured materials
- novel phenomena in non-centrosymmetric & related superconductors
- topological properties of unconventional superconductors, in particular for chiral superconducting phases
- electronic systems with non-trivial topological properties: Kondo- and other insulators & protected nodal excitation spectra
- correlation effects in electronic multi-orbital systems
- transport properties in correlated electron systems
- artificially structured strongly correlated electron systems, superlattices & heterostructures including their interface physics
- multiferroic spintronic systems & devices

Competences / Infrastructure

- General mean field & quasi-classical approaches to superconductivity
- General many-body & transport techniques
- Slave-boson & Gutzwiller approach to strongly correlated electron systems
- Group theory & topology for the analysis of complex electronic systems

ETH Zürich
Department of Physics
Strongly Correlated Electrons

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The Strongly Correlated Electrons Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

quantum phase transition | unconventional superconductivity | transport properties topological phases | many-body physics

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Materials and Processes

Structural Mechanics and Monitoring

Research Profile

The SMM Group couples novel simulation tools with state-of-the-art monitoring methodologies for intelligent and data-driven assessment of engineered systems, with the goal of providing actionable tools able to guide operators and engineers in the management of their assets. We extract explainable and quantifiable metrics that are indicative of structural performance across the component, system, and network levels. Our expertise lies in the area of Structural Health Monitoring, with a strong focus on problems lying beyond the commonly adopted assumption of linear time invariant systems. Our research spans a broad range of topics, including:

› Hybrid Modeling fusing Data & Models
› System Identification & Condition Monitoring
› Intelligent & Data-Driven Decision Support
› Curbing Uncertainties in Diagnostics and Prognostics
› Control & Metamaterials Solutions for Structural Vibration Mitigation
› Emerging Sensing Technologies

Competences / Infrastructure

› Simulation & Testing methods for Virtualization of Dynamics Systems
› Machine Learning for Structural Health Monitoring
› Monitoring-Powered Tools for Decision Support
› In-Service Monitoring of Operational Systems and Industrial Assets
› On-Board Monitoring for Transport Infrastructure
› Experimental Facilities for Vibration & Hybrid Testing
› Monitoring of Large-Scale Infrastructure

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Structural Mechanics and Monitoring

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virtualization | structural health monitoring
metamaterials for vibration mitigation
data-powered models | intelligent diagnostics

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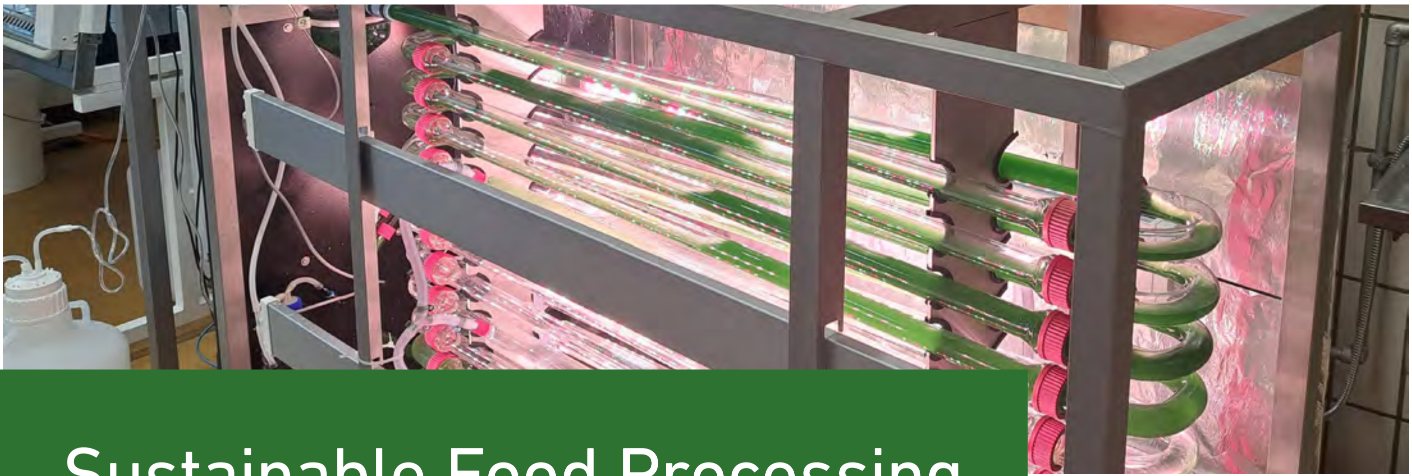

Sustainable Food Processing

Research Profile

The Sustainable Food Processing Group focuses on a system oriented approach in food production via the consideration of the total value chain including emerging needs in society and their environmental, economic and social impact. Sustainable Food Processing is part of the global bioeconomy. Life cycle sustainability assessment (LCSA) as guidance tool is the foundation of our emerging food process development. Selected mechanical, biotechnological, thermal and non-thermal techniques to realize several objectives such as (i) biomass and (ii) energy use efficiency, (iii) significant waste reduction along the food value chain and (iv) healthy and high quality food production are evaluated. Innovative raw materials from algae and insects are utilized within urban farming and processing concepts to enable new ways of sustainable food supply.

Competences / Infrastructure

- Emerging multi hurdle technologies for gentle preservation of healthy and high quality food
- Novel protein based biorefineries, with focus on algae and insects, for more sustainable food production
- Modular micro process engineering approaches to improve upscaling
- Nutritional combined environmental life cycle assessment
- Single cell production, such as microalgae, cyanobacteria, bacteria, and yeasts

ETH Zürich
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Sustainable Food Processing

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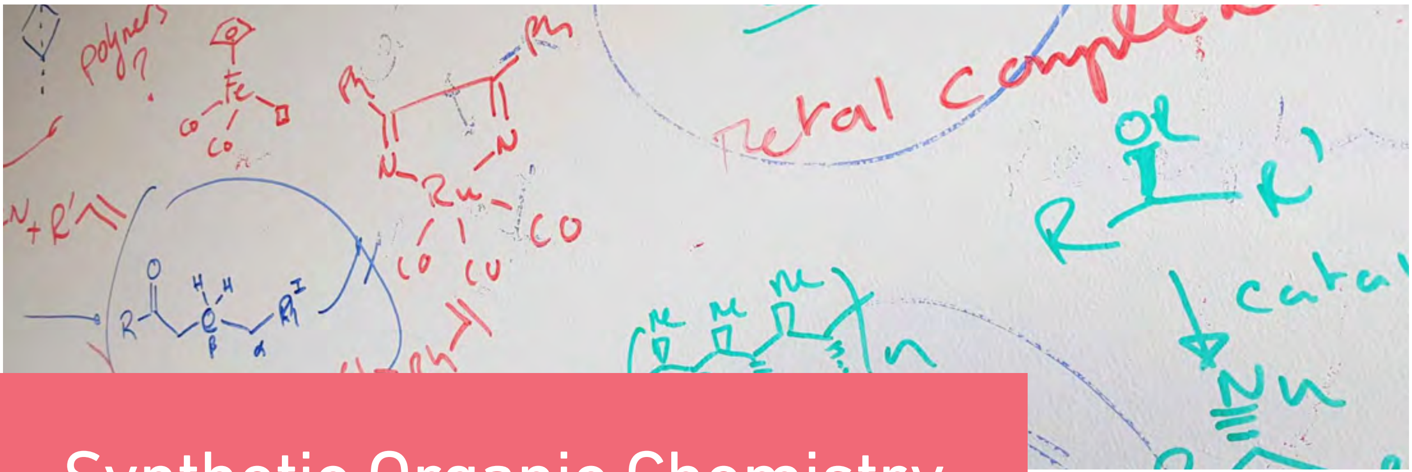
insects | high pressure | protein
micro process engineering
preservation | algae | sustainability



Synthetic Organic Chemistry

Research Profile

The group has a fundamental interest in developing innovative synthetic methodologies for applications across the molecular sciences, with a particular interest in establishing new concepts in catalysis. An interdisciplinary approach drawing from the areas of organic synthesis, organometallic chemistry, supramolecular chemistry and inorganic chemistry is used to rationally design innovative catalytic solutions to major synthetic challenges across the molecular sciences, e.g. the synthesis of bioactive compounds, sensing, polymer synthesis and recycling, as well as waste and biomass valorization. We are particularly interested by reversible catalytic reactions that provide unique ways to construct and deconstruct molecules.

Competences / Infrastructure

- Organic and Organometallic Synthesis
- Reaction Development
- Catalysis
- Mechanistic Studies

ETH Zürich
Department of Chemistry and Applied Biosciences
Synthetic Organic Chemistry

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homogeneous catalysis | waste valorization
organometallic chemistry | recyclable materials
organic synthesis | molecular editing | mechanisms

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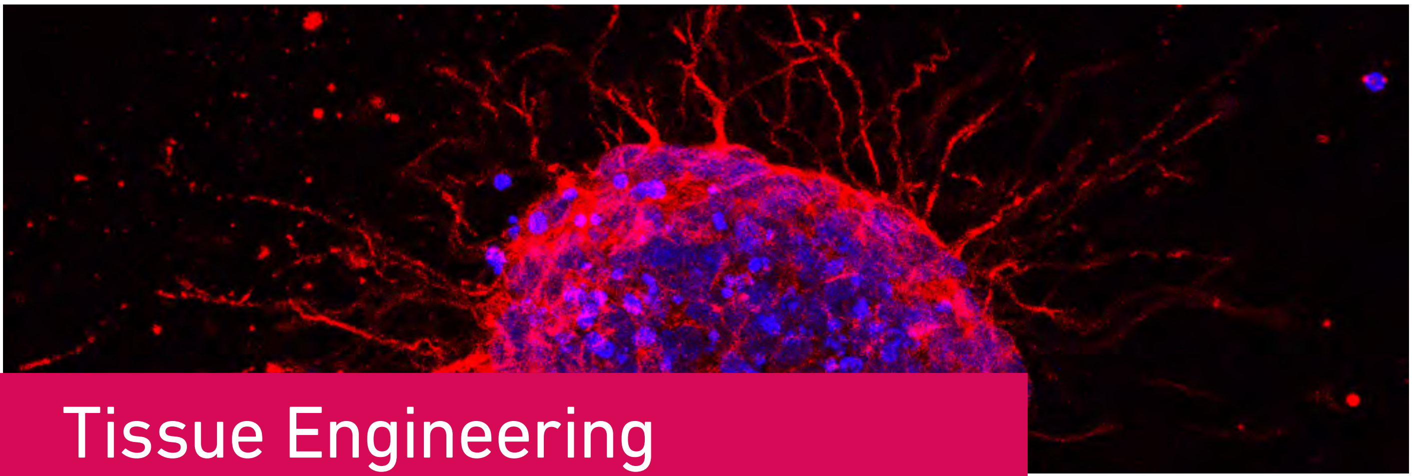

Tissue Engineering and Biofabrication

Research Profile

We develop biomaterials for use in regenerative medicine, with a particular emphasis on cartilage engineering. Our lab has developed a number of hydrogels to control the fate of the encapsulated cells, where gelation can be triggered optically, thermally, or enzymatically. Recently, we have extended our work to biofabrication techniques, including bioprinting, two photon polymerization and electrospinning. All this is designed to give the cells biophysical and biochemical cues which mimic their native environment. One of the most successful strategies is the addition of sulfate groups which confers natural growth factor binding properties to otherwise inert materials.

Successful tissue engineering also depends on the availability of cells which have strong regeneration potential, usually from young donors, and which are available in sufficient numbers. To the end, we use chondroprogenitors cells which can undergo significant growth without losing their phenotype.

The end goal of this work is to develop clinically-compliant strategies for tissue regeneration and repair.

Competences / Infrastructure

- Extrusion Bioprinting
- Hydrogel synthesis
- 3D Cell culture
- Electrospinning
- Rheology
- Cryomilling and tissue particle generation
- Histology and Immunohistochemistry
- Compression, tension and bending tests of structures
- Two-photon polymerization of hydrogels

ETH Zürich
Department of Health Sciences and Technology
Tissue Engineering and Biofabrication

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The Zenobi-Wong Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

tissue engineering | stem cells
biofabrication | cartilage | hydrogels

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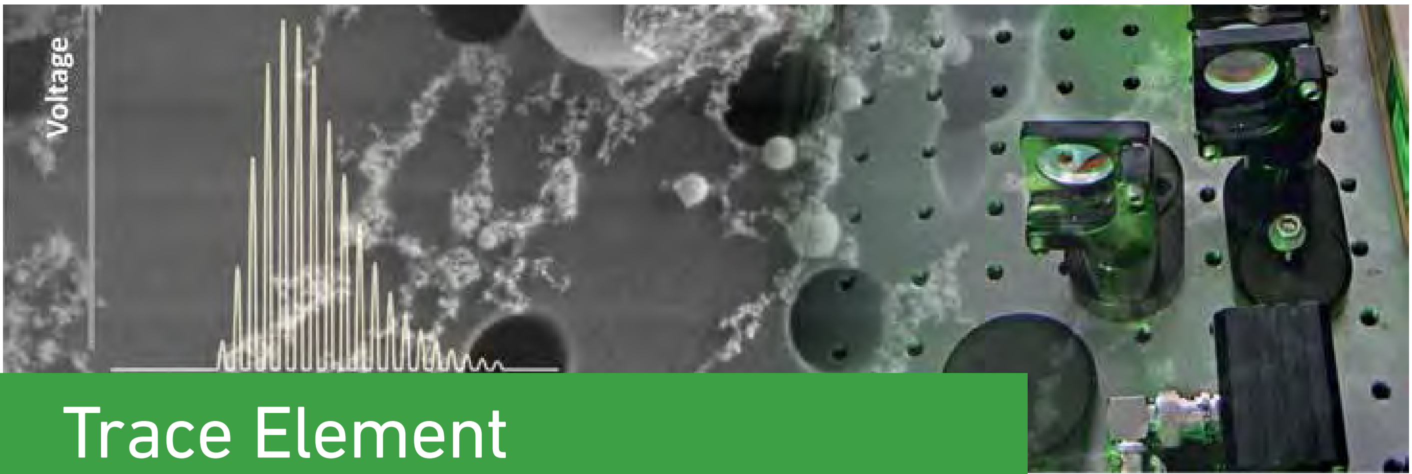

Trace Element and Micro Analysis

Research Profile

Fundamental and application-oriented research projects aiming at accurately measuring major, minor, and trace element concentrations of solid materials, solutions, or single nanoparticles (NP):

- Preparation-free, bulk and spatially resolved analysis of hardly soluble industrial, geological, or archaeological samples (e.g., certain ceramics, minerals, and glasses) by laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) using quadrupole (Q), sector field (SF), or Time-of-Flight (ToF) mass analyzer.
- Method development for the bulk and spatially resolved (1D depth profiling, 2D surface imaging, or even comprehensive 3D tomography) analysis of biological tissues and high-tech composites such as Perovskites, superconductors, next generation giant magneto resistance ceramics, or phase change materials.
- Examining expansion and transport phenomena of aerosols produced by nanosecond (ns) and femtosecond (fs)-LA applying laser scattering and shadowgraphic imaging
- Evaluation of laser homogenization and beam delivery optical schemes
- Design optimization of LA-ICP-MS aerosol transport systems by computational fluid dynamics (CFD)

Competences / Infrastructure

- Analysis of solids (bulk and spatially resolved), solutions and nanoparticle suspensions, micro polymer samples as well as single cells
- High resolution element- and isotope-specific analyses and imaging (lateral: > 1 um; depth 0.05 um)
- Structural and compositional characterization of aerosols produced by LA using conventional (ns-LA) and ultra-fast laser sources (NIR- & UV-fs-LA)
- Advanced analytical and microscopic techniques (AAS, ICP-OES, ICP-MS)
- Excimer (ArF) ns-LA homogenization optics, beam delivery, and sample observation

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Trace Element and Micro Analysis

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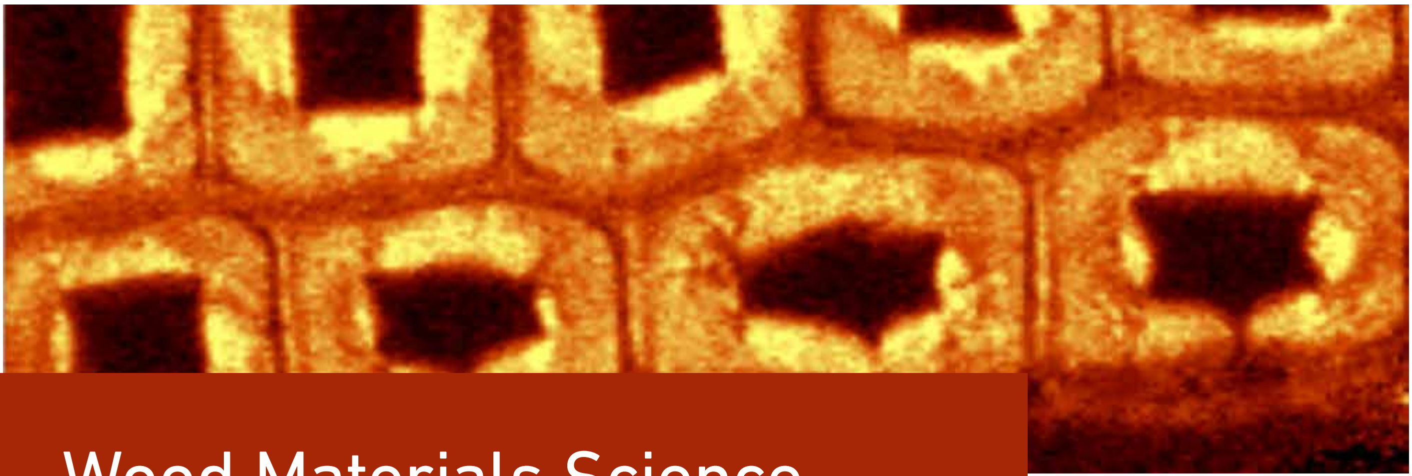
The Günther Group is part of the Competence Center for Materials and Processes (MaP). MaP brings together about 80 groups with research activities in the area Materials and Processes at ETH Zurich. More information at www.map.ethz.ch

computational fluid dynamics | isotope analysis
ns-/fs-LA | ICP-MS | trace element micro analysis

ETH zürich

MaP | Competence Center for Materials and Processes



Wood Materials Science

Research Profile

Wood is a natural and renewable resource with excellent mechanical performance in view of its low density but wider utilization as an engineering material is limited by unfavourable properties such as low dimensional stability and durability. The Wood Materials Science Group focusses on the modification and functionalization of wood and wood based materials utilizing biomimetic approaches and nano(bio)technology in order to improve the reliability of wood, optimize its property profile, and embed new functionality. Our research activities are the following:

- We investigate the structure and mechanical properties of wood and wood-based materials at all hierarchical levels. A specific focus is on gaining insight into the nanostructure, chemistry and mechanics of biopolymers and modified wood cell walls.
- We modify wood cell walls for improved dimensional stability, durability and surface properties by bulking voids and crosslinking polymers.
- We develop and characterize hybrid wood based composites for new functions and properties.
- We functionalize wood to equip it with new properties, such as electrical conductivity.

Competences / Infrastructure

- Combination of AFM and Raman to probe nanostructure, chemistry and nanomechanical properties of biopolymer-based materials
- Chemistry laboratories (wet chemistry, polymer synthesis)
- Custom-made equipment for micromechanical tests (single fibre tests)
- TGA, DSC, DVS for characterization of functionalized wood materials as well as wood-water interactions

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Wood Materials Science

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wood | smart wood devices | hybrid composites
cell wall modification | AFM/Raman analysis

MaP Competence Center for Materials and Processes

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