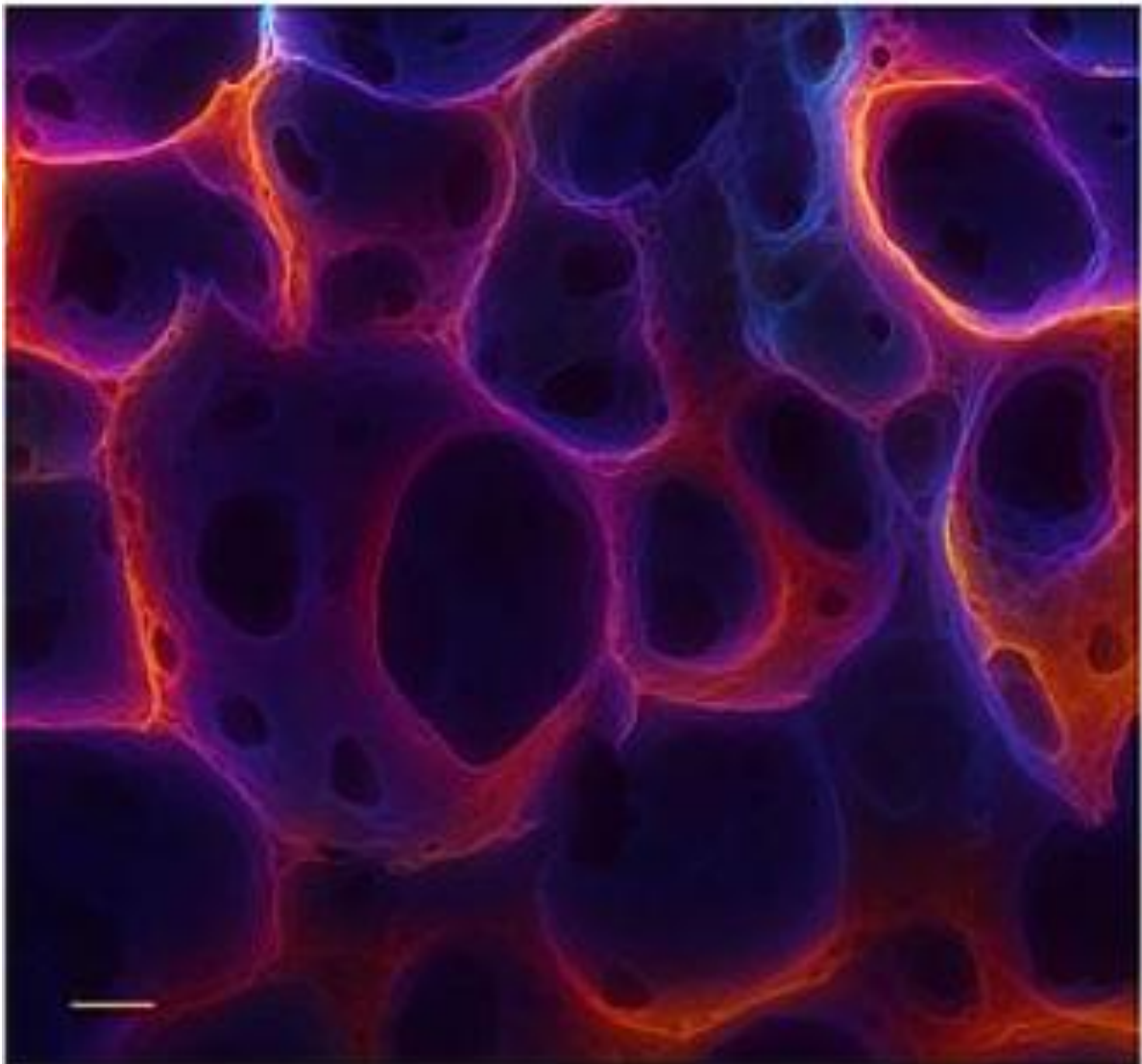


Kursbeschreibung

Blockkurse 2026/2027



Protein Foam (Sven Zaugg; FHNW, University of Basel)

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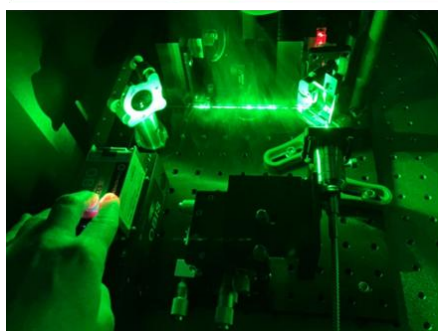
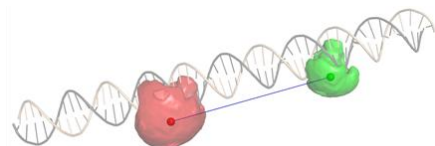
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A. Zeitdauer 3 Wochen, nachmittags, 3 KP pro Kurs

1. Single-molecule Förster Resonance Energy Transfer (smFRET) as a spectroscopic nano-ruler

S. Schmid

Pro Kurs 2 Studierende



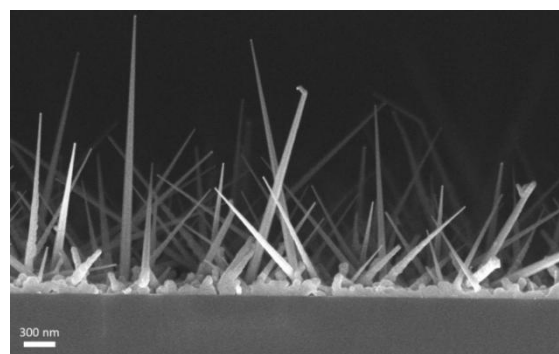
Single-molecule experiments can overcome the ensemble and time-averaging effects of conventional bulk experiments. We use Total Internal Reflection Fluorescence (TIRF) microscopy to detect hundreds of single fluorescent molecules in parallel. Förster Resonance Energy Transfer can be used as a nanoscopic ruler with high spatial (nm) and temporal (ns – ms) resolution to characterise conformational changes within single (bio-)molecules. In this block course, you will observe the conformational changes of single DNA Holliday junctions in real-time and measure nanoscopic distances by smFRET. You will prepare the biomolecular samples, measure smFRET at our state-of-the-art open-beam laser setup, and analyse your data to extract the relevant time-resolved trajectories. The learning goals of this course are: (i) knowledge of the additional information offered by single-molecule experiments compared to ensemble experiments; (ii) the physical basis of smFRET, the corrections for experimental crosstalk, and nanoscale distance derivation; (iii) kinetic rate

extraction from watching conformational changes in real-time; (iv) understanding the thermodynamics vs. kinetics of these dynamic molecular systems.

2.1 Synthesis of nanostructured materials

Ilaria Zardo

Pro Kurs 2-3 Studierende



Nanostructures have been extensively investigated in the last two decades as model systems for exploring the role of dimensionality and size in the electronic, mechanical, and optical properties of nanomaterials. Semiconductor nanowires (NWs) and thin films play a crucial role both for fundamental physics studies and for potential technological applications.

The most commonly used method for the synthesis of NWs from the gas phase is the catalyst-mediated Vapor Liquid Solid (VLS) method. In this technique, a metal seed is used as catalyst for the growth of NWs from a gas precursor. Gas-phase epitaxial synthesis not only results in NWs with high crystalline quality, but also allows controlling the NW length, diameter, radial and axial composition, and crystallographic structure. In our laboratories we have two (Plasma Enhanced) Chemical Vapor Deposition (CVD) systems, which enable us to synthesize Silicon and Germanium

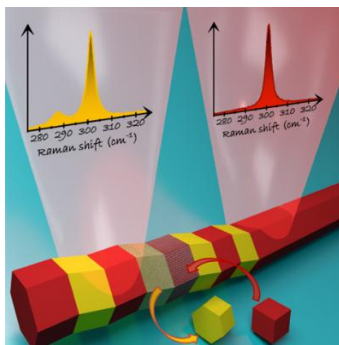
nanostructures as well as SiN_x and SiO_x thin films.

In this course you will learn how to operate a CVD system and prepare the substrate for nanostructures synthesis. Furthermore, the morphology of the obtained samples will be investigated by means of Scanning Electron Microscopy.

2.2 Spectroscopy of Phonons

Ilaria Zardo

Pro Kurs 2 or 3 persons



Phonons, which are quantized vibrations of atoms in crystals, are responsible for the transmission of sound and heat. Therefore, the capability to engineer phonons in condensed matter corresponds to the capability to tune the sonic and thermal properties of materials with applications such as medical ultrasound imaging machines, thermal insulation materials, thin acoustic metamaterials that can soundproof rooms, and enhanced thermoelectric devices that can use our bodies' waste heat to power portable electronic devices. Two ingredients are typically used to design the phononic properties of materials: i. The size of the structures and ii. The combination of different materials with different elastic properties.

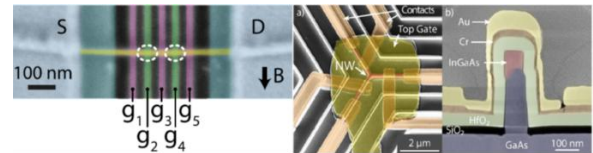
Inelastic light scattering spectroscopy enables the determination of lattice dynamics, chemical composition, strain

level, and some electronic properties of semiconductors, including nanowires.

In this course you will learn the physics of phonons, how to perform both spectroscopy experiments and the analysis of the experimental data.

Quantum Coherence Lab

D.Zumbühl



3.1 Semiconductor Nanofabrication Course

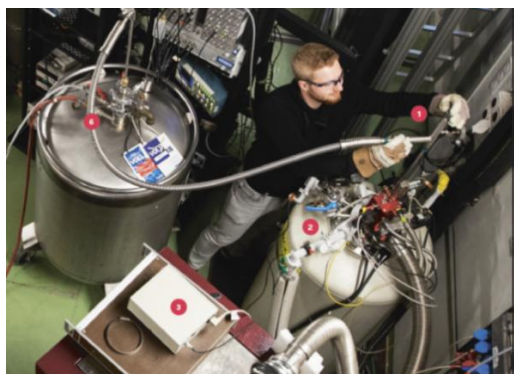
(groups of min. 2, max. 3 persons)

Over the past five decades, transistors made from semiconductors – Silicon, in particular – were scaled down to a size of only a few nanometers, allowing the integration of billions of transistors and thus bits on a single square centimeter chip. This has made possible today's computers and the information technology revolution. Today, we are working on using this same transistor technology for the development of quantum bits, or so called qubits, for quantum information processing. A quantum computer would take advantage of the unique resources of quantum mechanics, such as superposition and entanglement. This would give great computational power to the quantum computer, allowing to solve problems which are otherwise intractable.

The goal of this course is to provide insight and training of device fabrication for semiconductor nanostructures: you will fabricate a semiconductor sample – from the bare wafer to the completed sample – in our in-house clean room. This includes a number of different clean room processing steps such as etching, resist spinning, lithography, thin film deposition, contact definition, surface gating and wire bonding. The same methods are also used for sample

fabrication in ongoing research in our group. Finally, you will perform some electrical characterization of the sample in the cryolab at room temperature and 4.2 K in liquid helium

3.2 Quantum transport experiments Cryo-Lab Measurement Course (groups of min. 2, max. 3 persons)



Recommended prerequisite for this course:

Condensed matter physics. Ideally (but not mandatory), the Semicond. Nanofabrication Course is taken before the cryolab course.

Quantum transport is the study of quantum phenomena probed with electrical means, typically using nanoscale devices at low, cryogenic temperatures. Conductance quantization in 1D constrictions and the discrete energy levels of a tiny, isolated island forming a 0D system – a quantum dot – are some of the most striking phenomena in quantum transport experiments and are providing a basis for a quantum unit of information – a qubit. The spin of an electron (or hole) is of particular interest as a qubit. It forms a natural two-level system, well enough isolated from the environment to enjoy excellent coherence, yet it can be manipulated relatively fast and easily.

In this course, you will study one of these phenomena in our cryo lab. With the guidance of a teaching assistant, you will cool down a device to low temperatures in a cryostat or dilution refrigerator. You will

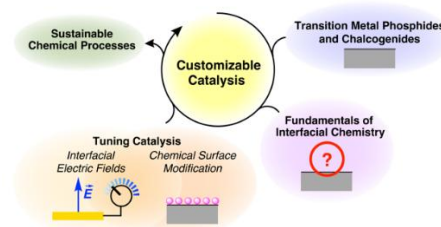
use low-noise electrical techniques and superconducting magnets to investigate the quantum physics. We will provide the samples. (In the Nanofabrication course, you can learn fabricating such devices).

Visit <https://Zumbuhllab.unibas.ch> for further information

4. Surface chemistry and heterogeneous catalysis

M.F. Delley

Pro Kurs 1Studierende

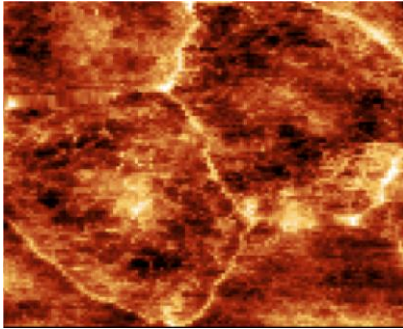


Heterogeneous catalysts are solid materials that are used to increase the rate of a chemical reaction without being consumed. This is a key component to most industrial chemical processes and the production of chemicals. In our lab, we study the surfaces of inorganic materials and their catalytic applications in order to understand how to develop better heterogeneous catalysts. This course will treat a current topic in this research area. You will learn about the synthesis and characterization of inorganic materials and their application to heterogeneous catalytic reactions. The focus may be on the synthesis, surface modification and characterization of an inorganic materials, such as transition metal phosphides, transition metal sulfides or transition metal oxides. Alternatively, the focus of the course could be on the application of such an inorganic material as a catalyst to a chemical reaction. A strong interest in practical inorganic chemistry is required for this course. More information can be found on the website of the Delley group: <https://delley.chemie.unibas.ch/en/>.

5. Methods in Nanobiology

R. Lim

Pro course max. 6 persons



Nanobiology attempts to resolve biological function from the “bottom-up”. Our research interests include nucleocytoplasmic transport control, its role in regulating cell and tissue mechanobiology, and how this phenomenon can be leveraged towards bio-inspired applications. Very often, our questions motivate us to develop new methodologies, which we combine in a multidisciplinary manner to be able to correlate different perspectives of a certain biological problem. In this Blockcourse, you will not only gain first-hand experience on the use of such cutting-edge instrumentation, but will more importantly learn how to ask biological questions from a nanoscience perspective. Ongoing projects include: studying the mechanobiology of cells and tissues using indentation-based atomic force microscopy (see Figure) and fluorescence microscopy, (ii) applying high-speed atomic force microscopy to visualize native nuclear pore complexes at work (iii) building artificial nanopores to study transport processes at the single molecule level.

6. Cell-material interactions and Tissue Engineering

G. Guex

Cell-material interactions and Tissue Engineering, Oral Implantology, UZB
For 1 to max. 2 persons

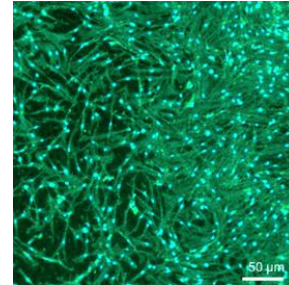


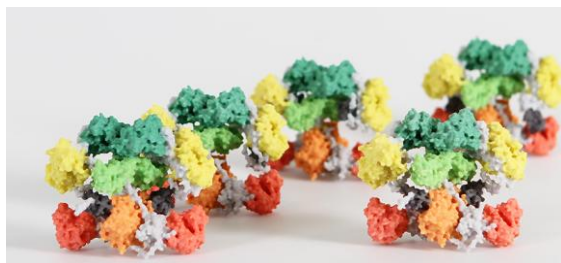
Figure 1: Fluorescence microscopy image of human gingival fibroblasts (HGF-1) cultured on a titanium-based substrate. Cells are stained with Phalloidin to label the actin skeleton (green) and with DAPI to stain nuclei (blue)

A thorough understanding of cell material interactions is paramount to design new implants or improve existing ones with functional coatings. This holds true in a plethora of applications and clinical situations, ranging from biografts to restore diseased or lost soft tissue to metal or ceramic-based implants in orthopaedics or oral implantology. By tuning the mechanical, physical, chemical or biological properties, implant surfaces can be designed to control cell fate and differentiation, soft-tissue adhesion, osseointegration or immune reactions. In this block course, you will learn the fundamental principles in tissue engineering, regenerative medicine and oral implantology. You will gain hands-on experience in material characterisation, cell culture, different analytical methods and fluorescence microscopy.

7. Structural Biology of Metabolic Regulation and Biosynthesis

Timm Maier, Roman Jakob & Nikolaus Dietz

1 course with 2 students

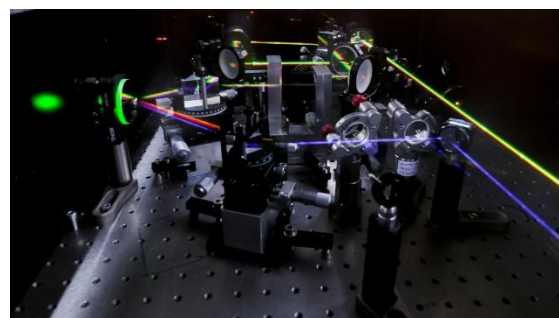


Synthesizing complex biomolecules, such as antibiotics, and regulating metabolic processes inside cells requires a fine-tuned choreography of multiple proteins. The contributing proteins team up with their individual functions to create biological “computers” and “factories” with emergent properties beyond the sum of the properties of the individual protein parts. Studying such protein assemblies requires both, a high resolution in the 0.3nm range to resolve amino acids and to build and refine models of 1000s to 100000s of atoms in the computer, as well as a broad coverage of samples in different states to comprehensively explain protein function. In this block course, the students learn with hands-on experience all fundamental steps required to reveal fundamental mechanisms in biology, from protein sample preparation, via electron microscopy imaging to computational data processing and structural analysis. Specific focus areas will be defined with the participants in either biological workflow automation, computational data processing or structural modelling and interpretation.

8. Ultrafast optics and spectroscopy

M. Oppermann

Pro Kurs 1 student



The defining goal of ultrafast spectroscopy is to capture the molecular transformations that drive (bio-)chemical processes in real-time. For light-activated phenomena, this typically requires techniques with femtosecond (1 femtosecond = 10^{-15} seconds) resolution – the natural time scale of the vibration, formation and breaking of chemical bonds, and the fastest photon-energy conversion phenomena, such as photoisomerization, and intramolecular energy and electron transfer. To resolve such processes, modern ultrafast techniques employ short pulses of light or electrons in a so-called pump-probe scheme: a first pump pulse photo-excites the molecular system and a second pulse, called the probe, records its response at variable time delays between the pump and probe pulses. In this block course, you will first learn the fundamental concepts and laboratory skills to generate pump and probe pulses via nonlinear frequency conversion processes, such as second harmonic generation and self-phase modulation. In the second part, you will perform pump-probe absorption measurements and learn the required data analysis tools to follow a photochemical process with femtosecond resolution.

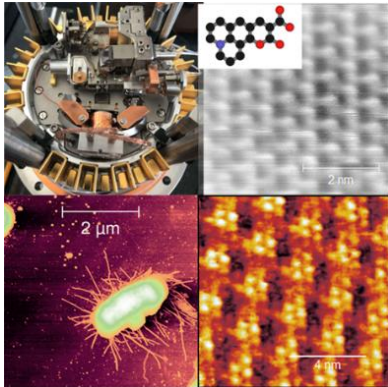
Group website:

<https://oppermann.chemie.unibas.ch>

9. Scanning Probe Microscopy

E. Meyer/T. Glatzel

Pro Kurs 4 Studierende



Atomic Force Microscopy (AFM) is nowadays established as a powerful tool being able to determine a large variety of samples properties. The technique is commonly used in many physics, chemistry and biology laboratories. AFM is operating in several dynamic and static modes and in various environments, namely vacuum, ambient and liquid. Thus, it allows to obtain informations about surface topography, surface chemical composition, sample elasticity, frictional behaviour, electrical charge localization, contact potential, magnetic domains behaviour and many more.

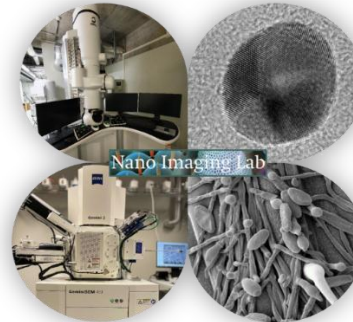
Within the Blockkurs recent progress in the field of Scanning Probe Microscopy is discussed and relevant experiments are performed. The students will have opportunity to learn various Atomic Force Microscopy (AFM) techniques. The main focus is put on dynamic modes, which allow to study surfaces in a minimally invasive way. The various microscopes allow to study metallic, insulating, organic and biological samples under ambient, liquid and ultra high vacuum conditions. Sample surface might be investigated down to the atomic scale, which in turn allows to determine the defect densities, the structure of molecular self-assembled networks or the behaviour of charge density wave (CDW) systems. In ambient or liquid environments AFM could characterise the mechanical or electric properties of

polymer structures or even the bacteria cell. During the training the students will also obtain knowledge about various sample preparation techniques.

10. Nanoscopic imaging and analysis

M. Wyss

Pro Kurs 2 Studierende



The characterization of nanoscale devices is an essential aspect of industrial development and scientific research. One of the most common set of techniques applied in this context are those based on electron microscopy, as they allow for the visualization and compositional analysis of materials down to the atomic scale. In this course, the students are introduced to a variety of characterization techniques on the micro- and nanoscale. You will receive basic training in scanning electron microscopy (SEM) and focused ion beam technology (FIB) and operate them independently. The aim of the course is to create a gold nanostructure using electron beam-induced deposition (EBID). Subsequently, the deposited structure will be characterized using conductivity measurements, transmission electron microscopy (TEM), scanning transmission electron microscopy (STEM), selected area electron diffraction (SAED) and energy dispersive X-ray spectroscopy (EDX). Additionally, you will gain insights into confocal laser scanning microscopy

(CLSM) and atomic force microscope (AFM) through a half-day demo, to deepen your understanding of complementary imaging techniques and their respective strengths and weaknesses.

<https://nanoscience.unibas.ch/de/services/nano-imaging-lab/>

11. Nanostructuring / Coating by Plasma

Laurent Marot / Ernst Meyer

Pro Kurs 2 or 3 Students



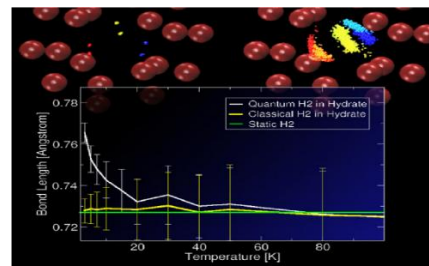
Coating and nanostructuring is way to modify surfaces to achieve new properties. In the course, you will learn how to deposit a thin film of a substrate using the magnetron sputtering technique. The film will be characterized without breaking the vacuum by X-ray photoelectron spectroscopy (XPS) to analyze the chemical composition. Depending on the properties to be achieved (antibacterial...), plasma treatment will follow to nanostructure the surface. Imaging of the surface will be performed by scanning electron microscopy (SEM). You will learn about these techniques and also to be used to vacuum equipment. Thin film growth, interaction of ions and surfaces, and plasma characterization will be the focus of the course. Depending on the topic, new surfaces/materials of are interest for fusion reactor (left image), antibacterial surfaces for implants (left image), or new thin film properties.

<https://nanolino.physik.unibas.ch/en/research-1/topics/plasma-surface-interaction-for-fusion-application/>

12. Atomistische Simulationen

M. Meuwly

Pro Kurs 2 Studierende

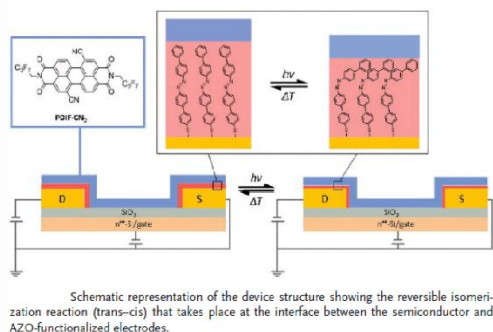


Dieser Blockkurs gibt Einblick in die Durchführung und Analyse von Molekulardynamik Simulationen mit spezifischen Anwendungen auf Fragestellungen der kondensierten Materie. Mögliche Themen beinhalten die Untersuchung von Proton-Transfer Reaktionen, das dynamische Verhalten von Wassermolekülen in räumlich einschränkenden Umgebungen (Proteine, Buckyballs, Nanotubes), oder die Bestimmung des Infrarot Spektrums von kleinen Liganden in Myoglobin. Für die meisten Simulationen verwenden wir eine QM/MM (quantum/ classical force field) Methode zur Beschreibung der elektronischen Struktur. Im Vordergrund der Rechnungen steht dabei, experimentell zugängliche Größen mittels MD Simulationen zu bestimmen. Das Thema des Blockkurses wird mit den Teilnehmenden in einer kurzen Besprechung einige Tage vor Beginn des Kurses festgelegt. Weitere Themen (z. B. mehr biologisch orientiert) können auf Wunsch hingefunden werden. Programmierkenntnisse sind nicht nötig. Es lassen sich jedoch auch Themen finden, welche explizit die Programmierung in C++, Fortran, perl oder python erfordern. Weitere Informationen und Beispiele aus früheren Blockkursen finden Sie unter www.chemie.unibas.ch/~meuwly/mdnano_block.html

13. Nanochemistry

M. Mayor

Pro Kurs 1 Studierende/r



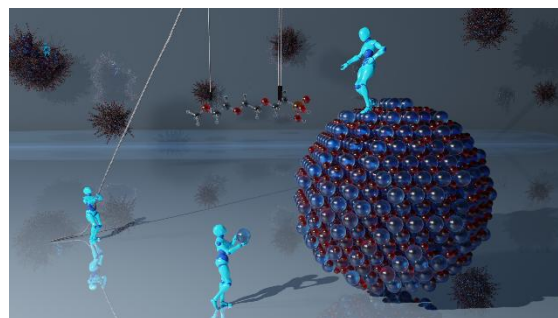
In diesem Blockkurs werden die Kenntnisse des Praktikums Organische Chemie vertieft. Wir geben einen Einblick in die praktische Arbeit des Synthese-Chemikers. In mehreren Schritten wird ein Zielmolekül synthetisiert. Neben der Synthese steht auch die Isolierung, Analyse und vorherige Planung der Arbeit im Fokus. Das Zielmolekül ist jeweils Teil eines aktuellen Forschungsprojektes der Arbeitsgruppe Mayor und kann einem der folgenden Forschungsbereiche zugeordnet werden: Molekulare Elektronik, Gezielte Funktionalisierung von Oberflächen (siehe Bild), Quanten-Eigenschaften von organischen Molekülen, Molekulare Textilien, Chirale Moleküle und deren optische Eigenschaften. Genauere Information zu den einzelnen Bereichen, können auf der Homepage nachgelesen werden:

<https://mayor.chemie.unibas.ch/en/>

14. Nanocrystals and oxo clusters

J. De Roo

Pro Kurs 2 Studierende



Nanomaterials have emerged as one of the most exciting frontiers in modern science, offering vast potential for applications ranging from nanomedicine to catalysis and environmental remediation. In this course, students will explore the bottom-up synthesis of group 4 oxide colloidal nanocrystals, learn how to design more complex nanocrystal architectures, and master techniques for surface functionalization.

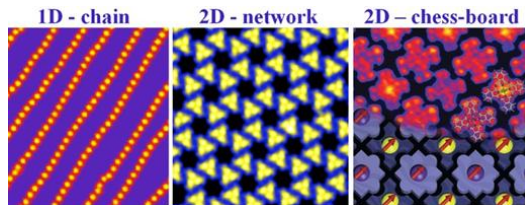
To characterize these materials, we will use a powerful toolkit including NMR, photoluminescence spectroscopy, and TEM imaging. The course also covers the synthesis and functionalization of atomically precise oxo nanoclusters, which serve as fundamental building blocks for Metal–Organic Frameworks (MOFs). Both oxo clusters and MOFs play key roles in catalytic and environmental applications — particularly in clean water technologies such as arsenate and PFAS removal. Their properties will be investigated through FT-IR and NMR spectroscopy, among other methods.

<https://deroo.chemie.unibas.ch/en/home/>

15. Nanolab: Physikalische und chemische Quantenphänomene am einzelnen Atom oder Molekül

N. Devi, A. Ahsan, T. A. Jung

Pro Kurs 6 Studierende (Intensivkurs 'nach flexibler Absprache')



Voraussetzungen: Interesse für NanoChemie/Physik und Oberflächen/Grenzflächen; disziplinenübergreifende Forschung.

Veranstaltungsort: Nanolab an der Uni Basel, <http://nanolab.unibas.ch/>

Projektbeschreibung:

Anhand eines aktuellen Forschungsprojektes werden Sie in oberflächenphysikalische und oberflächenchemische Präparationstechniken, Instrumente und Charakterisierungstechniken eingearbeitet. Sie lernen dabei wie sich Atome und Moleküle auf atomar sauberen Oberflächen anordnen und werden einige lokale Experimente zum Studium von Elektronenzuständen, Orbitalen und Spindichten/Magnetisierungen kennenlernen. Die Blockkursteilnehmer werden in die Forschungsarbeit des Teams integriert. Mehrheitlich haben Projekte Bezug zur Grundlagenforschung, aber bei entsprechendem Interesse kommen auch anwendungsnahe Projekte in Frage.

Zwei grundlegende Fragestellungen stehen im Vordergrund:

1.) Die Erzeugung von Polymerarchitekturen durch eine Kombination von supramolekularer

Chemie, Koordinationschemie und kovalenter Chemie an Oberflächen.

2.) Das Studium der Eigenschaften von Elektronen, magnetischen Momenten in einzelnen Atomen oder Molekülen und deren Wechselwirkung innerhalb dieser supra-molekularen Architekturen.

Für den Bericht soll unter Anleitung und selbständig nach weiterführenden Beiträgen in der aktuellen wissenschaftlichen Literatur gesucht werden. Anhand dieser Referenzen sollen die verfügbaren Daten interpretiert und diskutiert werden.

Planungsinformationen:

Blockkurs, 1 Woche Vollzeit oder aequivalent, im Nanolab/Departement Physik der Uni Basel.

~2 Studierende pro Block, maximal 8 Studierende pro Semester; Zeitfenster nach Absprache, auch während der Semesterferien möglich.

Weitere Informationen / typische Projekte / Stellenausschreibungen:

<http://nanolab.unibas.ch/>

E-mail: thomas.jung@psi.ch

17. Quantum transport at cryogenic temperatures

Andrea Hofmann

Pro Kurs min. 2 max. 3 students



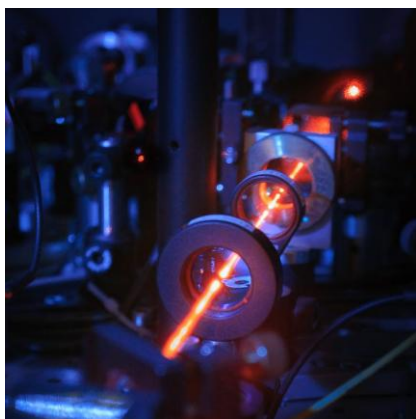
Our everyday live takes place in three dimensions, at about room temperature, and

in the small earth magnetic field. If we confine electrons into two dimensions, cool them down to low temperatures and apply magnetic fields, their flow (the current) exhibits interesting quantum features. The current flows in edge channels along the boundaries and situations arise where the conductivity and the resistivity simultaneously are zero. In this course, you will join us in cooling down semiconducting samples to temperatures near absolute zero and to investigate the emerging quantum behavior in electron transport.

20. Quantum optics and atomic physics

Philipp Treutlein

1 course with 3 students



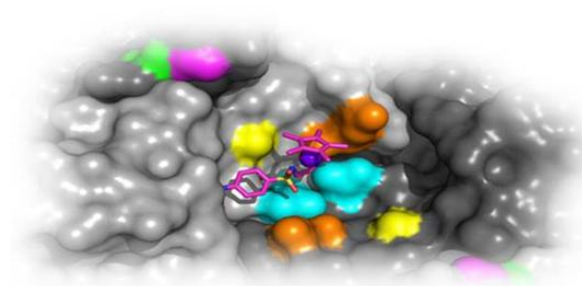
Atoms are quantum systems par excellence, and the laser manipulation of the quantum state of atoms has led to many scientific and technological breakthroughs. This includes the observation of Bose-Einstein condensation, the development of atomic clocks and atomic precision sensors, and experiments on quantum information processing and quantum technology. In this course, you will learn some basic experimental techniques that are used in many modern atomic physics and quantum optics laboratories. For example, you will operate an external-cavity diode laser, learn how to frequency-lock such a laser to an atomic resonance, and perform some basic experiments with it. In the second part of

the course, you will have a chance to get some hands-on experience on a more advanced laser setup, closely guided by one of the researchers in the group. The specific topic will be individually defined every year. Possible topics include laser cooling of atoms in a magneto-optical trap, optomechanics experiments with a nanomechanical membrane, and studies of coherent spin dynamics in a microfabricated atomic vapor cell. Prerequisites for the course: basic knowledge of optics, atomic and quantum physics.

21. Engineering protein-hosts for transition metal catalysts

Thomas R. Ward

Pro Kurs 1 Studierende



Die Derivatisierung von Übergangsmetallkomplexen mit Gruppen, die mit hoher Affinität an Gastproteine binden, ermöglicht die spezifische Lokalisierung katalytischer Komplexe in Proteingerüsten. Durch Mutation der Proteinhüllen kann die Funktionalität der Metallkomplexe massgeblich beeinflusst werden. Der Kurs bietet die Möglichkeit eines Einblicks in:

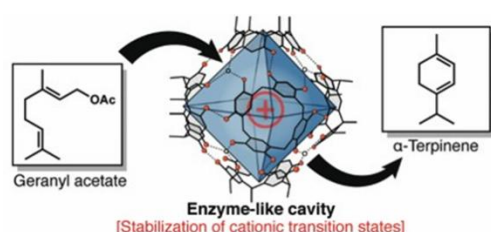
- 1) molekularbiologische Arbeitsweisen
- 2) die Synthese von Übergangsmetallkomplexen und relevanten Substraten die Durchführung von Katalyseexperimenten mit Protein-basierten Hybridkatalysatoren analytische Techniken für die Reaktionskontrolle und die Bestimmung von Affinitäten, Umsätzen, Enantiomerenüberschüssen und Reaktions-

geschwindigkeiten (HPLC, UPLC-MS, GC, UV-Absorption, Fluoreszenzintensität) die Visualisierung der Konstrukte basierend auf Röntgenstrukturen mit z.B. pymol®. Die Teilnehmer werden zusammen mit Mitgliedern der Arbeitsgruppe Ward auf aktuellen Projekten arbeiten. Die Behandlung der aufgelisteten Punkte im Rahmen des Praktikums hängt vom individuellen Projekt ab.

24. Nanoreaktionskammern

Konrad Tiefenbacher

Pro Kurs max. 1 Studierende



Für diesen Blockkurs ist ein hohes Interesse an synthetischer organischer Chemie (Praktikum Organische Chemie) notwendig. In diesem Kurs wird ein aktuelles Thema im Bereich von organischen Nanoreaktionskammern bearbeitet. Nanoreaktionskammern sind molekulare Strukturen im Nanometerbereich, die einen Hohlraum besitzen und Substrate in dieser Kavität einschließen können. Durch nicht-kovalente Wechselwirkungen des Substrates mit der Nanoreaktionskammer können Reaktionen beschleunigt werden bzw. Selektivitäten moduliert werden. Dadurch kann es gelingen die Funktionsweise von natürlichen Enzymen mittels deutlich einfacher Strukturen nachzuahmen. Im Rahmen des Blockkurses gewinnt man Einblick in die Synthese von Nanoreaktionskammern und geeigneter Substrate. Neben der Synthese spielt auch die chromatographische Aufreinigung und die Analyse der Verbindungen eine wichtige

Rolle. In dem Kurs wird eines der folgenden Themen bearbeitet:

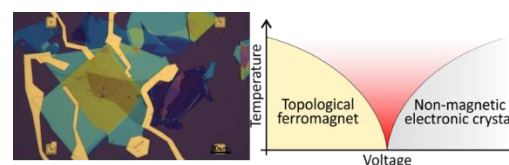
- Synthese von Bausteinen für den Aufbau von Nanoreaktionskammern bzw. -
- Synthese von Substraten für katalytische Umsetzungen in Nanoreaktionskammern. Zusätzliche Informationen zu dem Thema sind auf der Homepage der Arbeitsgruppe Tiefenbacher zu finden:

<https://nanocat.chemie.unibas.ch/en/>

25. Design and fabrication of artificial quantum materials from layered crystals

Tomasz Smoleński

2-3 Students



Uncovering and understanding new phases of matter is at the heart of condensed matter physics. Just like birds can form a flock by observing their neighbors, similarly electrons inside a crystal can form unexpected collective phases, such as superconductors or ferromagnets, which are extremely interesting from both fundamental and application perspectives. However, in conventional materials, the collective properties of electrons are hard to tune, which is in turn a key towards making functional devices. This can be resolved by building new quantum materials from atomically-thin layers. This method enables creation of artificial, highly-tunable heterostructures with otherwise inaccessible properties, in which electrons can be converted, e.g., from topological ferromagnets to non-magnetic crystals simply by varying the voltage!

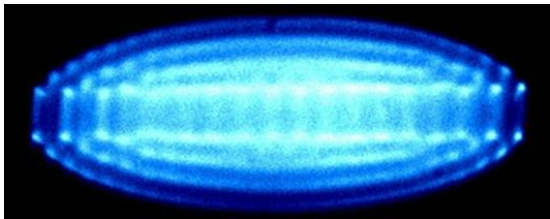
The goal of this course is to learn how to design and make such a van der Waals heterostructures. You will fabricate it

yourself, by first exfoliating individual atomically-thin layers from various bulk crystals (e.g., graphite), examining their properties with various characterization tools (such as optical and atomic force microscopy), and finally combining them together with a use of a polymer-stamp. For more information, please visit smolenski-lab.com.

27. Ultracold Ions

Stefan Willitsch

1 course with 2 students



Atomic and molecular ions stored in electrodynamic traps at temperatures close to the absolute zero point exhibit unusual properties. At these low temperatures, the ions localize in space so that they can be individually observed, addressed and manipulated. These intriguing features pave the way for a range of diverse and exciting applications such as the study of chemical reactions with single molecules, the development of quantum computers and the extremely precise measurement of molecular properties.

In this course you will learn to use methods such as laser cooling to cool ions down to temperatures of a few millikelvin and to store them in ultrahigh vacuum using ion traps. You will study the properties of the ultracold ions and explore some of their applications. The specific topics of the course will be closely aligned with the ongoing research in the group and will be individually defined every year according to the current research projects.

29. Bioaerosole detektieren und quantifizieren

Markus Kalberer

Pro Kurs max. 2 Studierende

Die Covid-19 Pandemie hat deutlich gezeigt, dass es von grosser Bedeutung ist Pathogene in der Luft (sogenannte Bioaerosole) zu charakterisieren zu messen und zu verstehen. Bioaerosole sind Viren, Pilzsporen und Bakterien die in der Luft als Aerosol schweben und sich somit schnell verbreiten können. In diesem Blockkurs wird ein Einblick in die aktuelle Forschung zur Messung von Bioaerosolen gewährt.

In diesem Projekt, in dessen Rahmen der Blockkurs stattfindet, wird ein Gerät entwickelt, in dem Antikörper Bioaerosole spezifisch aus der Luft aufkonzentrieren und dann mit einem Flow Cytometer detektieren und quantifizieren.

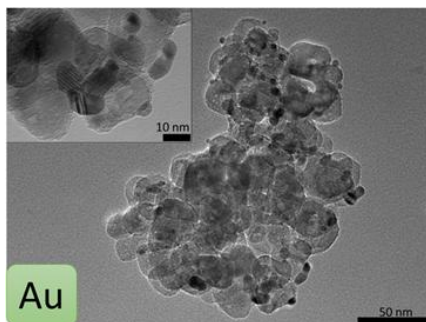
Es werden grundlegende Methoden der Mikrobiologie angewandt, kombiniert mit Messmethoden aus der Atmosphärenchemie um neuartige Methoden zu entwickeln zur Detektion von Bioaerosolen.

Welche Teilaspekte im Rahmen des Blockkurses behandelt werden, hängt von den aktuellen Fragestellungen im Forschungsprojekt ab.

30. Nanopartikel zur Katalyse von CO₂

Markus Kalberer

Pro Kurs 2 Studierende



Der Klimawandel ist eines der dringlichsten Probleme in unserer Zeit. Nebst der Reduktion des Ausstosses von CO₂ sind wir auch angewiesen auf die Entfernung von CO₂ aus der Atmosphäre.

In diesem experimentellen Blockkurs wird ein Einblick gewährt in die aktuelle Forschung bei der Nanopartikel verwendet werden um katalytisch CO₂ zu reduzieren. Es werden Methoden angeschaut um Nanopartikel unter kontrollierten Bedingungen herzustellen und diese dann auch mit verschiedenen Techniken zu messen, quantifizieren und charakterisieren. Des Weiteren werden diese Nanopartikel verwendet um photokatalytisch CO₂ zu reduzieren.

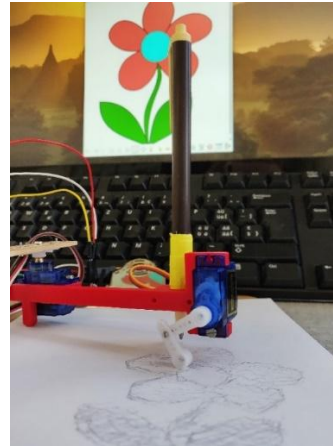
In diesem Blockkurs werden grundlegende Messmethoden der Atmosphärenchemie angeschaut und angewendet um ein besseres Verständnis dieser Prozesse zu erlangen.

Welche Teilaspekte im Rahmen des Kurses behandelt werden, hängt von den aktuellen Fragestellungen im Forschungsprojekt ab.

32. Measurement Control and Acquisition

Martino Poggio

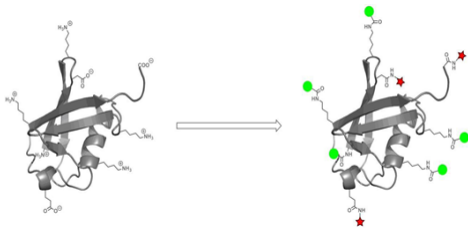
Pro Kurs min . 2 and max. 4 students



The purpose of this course is to teach students the practical aspects of how to run a measurement in the lab, control devices and do data acquisition. The technological development in the recent years made equipment such as microcontrollers, computers and sensors available for the mass market, that are designed for do-it-yourself experiments that can be taken out at home. This allows to do typical lab tasks with equipment that is accessible to everybody, which is why the single-board computer Raspberry Pi is used in this course. Subjects such as analog-to-digital conversion, sensor read-out, robotics and aspects of control theory in form of a PID loop will be addressed. A major part of the course is to get basic knowledge in the programming language Python, which will be used to perform the tasks and experiments in the course. Python is a high-level programming language, comparably easy to learn and widely used in the scientific community, and hence its mastery is a very useful skill for anyone interested in working in an experimental laboratory.

33. Altering protein and peptide properties by chemical modification

Valentin Köhler/ Marcel Mayor
Pro Kurs 1 Student



Proteinen können ganz allgemein durch ihre chemische Modifikation zusätzliche Eigenschaften verliehen werden, während gleichzeitig ihre natürlichen Eigenschaften verändert werden. Obwohl die Wahl der einführbaren Funktionen in erster Linie nur durch die Fantasie des Forschenden beschränkt ist, sind Proteinmodifikationen trotz etablierter Methoden nicht trivial. Gründe hierfür liegen in dem hohen natürlichen Funktionalisierungsgrad der Oberfläche von Proteinen, der unterschiedlichen Umgebung identischer funktioneller Gruppen, sowie in der Schwierigkeit Reaktionsbedingungen zu finden unter denen beide Reaktionspartner sowohl ausreichend stabil als auch reaktiv sind. Der Kurs ist in ein laufendes Forschungsprojekt eingebunden in dem wir versuchen den Ladungszustand von Proteinen und Peptiden in der Gasphase durch gezielte Photospaltung von speziell eingeführten Gruppen zu kontrollieren. Die physikalischen Untersuchungen, deren Ziel Quanten- Interferenzexperimente an Biomakromolekülen sind, werden von einer befreundeten Forschungsgruppe in Wien durchgeführt.

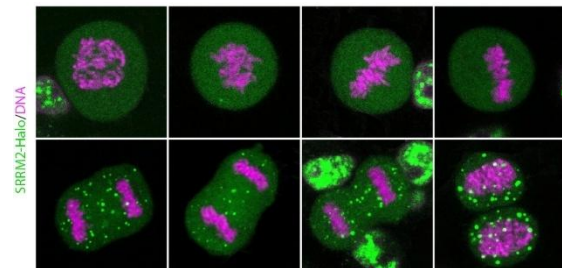
Im Rahmen des Forschungsprojektes werden:

- Proteine (rekombinant) und Peptide (synthetisch) hergestellt und charakterisiert
- Funktionalisierte Moleküle für die Derivatisierung der Proteine und Peptide synthetisiert und charakterisiert (NMR, MS, etc.)
- Proteine und Peptide mit den dargestellten funktionalisierten Molekülen derivatisiert
- Die erhaltenen Konstrukte mit verschiedenen Methoden (z.B. präparative HPLC) gereinigt und mit verschiedenen analytischen Methoden charakterisiert (UPLC-MS). Welche Teilaspekte im Rahmen des Kurses behandelt werden hängt von den aktuellen Fragestellungen im Forschungsprojekt ab.

34. Dynamics of biomolecular condensates in living cells

Maria Hondele

1 course with 1 student



Biomolecular condensates such as nuclear speckles organize key steps of RNA metabolism in the nucleus. During mitosis, these structures undergo extensive disassembly and reassembly, providing a unique system to study how dynamic molecular assemblies are regulated in space and time.

In this block course, students will investigate nuclear speckle dynamics in living cells using advanced fluorescence

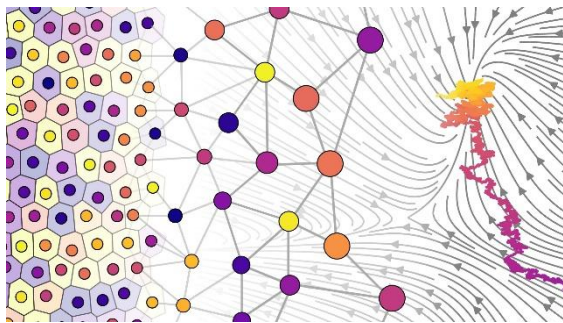
4. Diastereoselektive Herstellung von Oligomeren (Bild)
5. Charakterisierung durch Röntgenstrukturanalyse
6. Anwendungen in der Nanochemie

Die Teilnehmer werden diese Themen anhand eines aktuellen Forschungsprojekts bearbeiten

38. Collective dynamics of multicellular systems

David Brückner

1 student per course



The development of an organism from a single cell into an embryo is a spectacular display of self-organization, driven by the collective dynamics of cells that interact mechanically and biochemically to sculpt tissue shape and pattern cell fates. How cells obtain sufficient information to make reliable fate decisions despite stochastic fluctuations at all scales remains a key open question. Our group develops theoretical approaches grounded in statistical physics and information theory to understand how multicellular systems generate and transmit information in space and time.

This computational block course will focus on a current topic in the group. The particular project will change each year, but will broadly fall within the following areas: image analysis of collective cell dynamics in organoids, mathematical modeling of pattern formation in tissues, or machine learning approaches connecting biophysical models to quantitative experimental data.

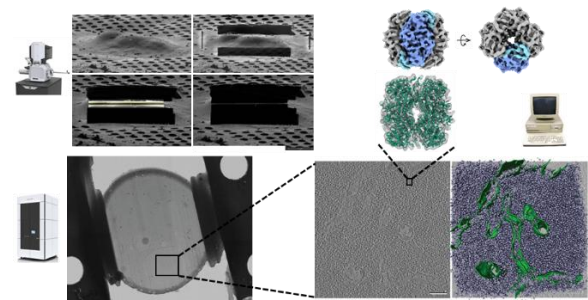
Students will work closely with group members on an ongoing research project.

Prerequisites: solid background in theoretical and mathematical methods; strong interest in biology; significant coding experience (e.g. Python).

41. Ultrastructure of the algal CO₂ concentrating mechanism

Ben Engel, Philippe Van der Stappen

1-2 students per course

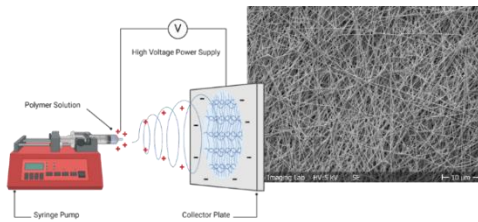


Photosynthetic algae concentrate CO₂ using specialized membraneless organelles called pyrenoids formed through the process of biomolecular condensation. Rubisco – the most abundant protein on Earth – is the main component of pyrenoids and catalyzes the reaction of CO₂ to sugars. Algae and their pyrenoids are essential for global carbon fixation, producing 70% of the atmospheric oxygen and fixing half of the global CO₂.

The project will explore the ultrastructure of pyrenoids formed by biomolecular condensation using high-resolution electron microscopy. Students will gain hands-on experience in algal cultivation and learn about cryo-focused ion beam milling combined with cryo-electron tomography. The course emphasizes on computational data processing and image reconstruction as well as the analysis of tomographic volumes.

42. Tuneable electrospun membranes for tissue engineering

G. Guex, M. Nash, I. Imhof
Pro Kurs 2 Studierende

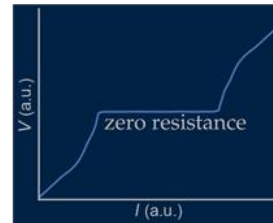


Electrospinning is a technique that produces nanofibers by applying a high-voltage field to a polymer solution extruded through a nozzle. The resulting nanofibrous scaffold can be used for various purposes such as tissue engineering applications. In this course we will focus on how the scaffold architecture can be fine-tuned depending on different polymer types and spinning parameters. For example, the addition of sacrificial polymers leads to increased pore size, which changes scaffold properties. We will explore different characterisation methods such as rheology, and drop-shape analysis. The fibre diameter and scaffold morphology will be assessed by Scanning Electron Microscopy (SEM). Depending on progress and feasibility we look at early adhesion of cells on the scaffolds with fluorescence microscopy or SEM.

43. Supercurrent measurements

Andrea Hofmann

Pro Kurs min. 2 max. 3 students



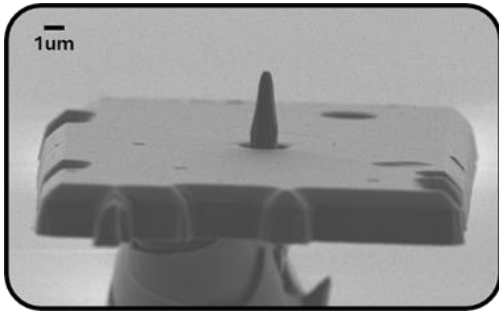
Transistors can switch or amplify electric signals and thus are the basic building blocks of today's technology. They are made out of semiconductors. Superconductors build another important class of materials: they carry current without resistance. If we combine superconductors with semiconductors, we can build a switch, where no current flows in the "off" state and a supercurrent flows in the "on" state. In this project, you will be working with these kinds of devices. The exact work you will carry out depends on the state of the research project in our group: you will help to answer a current research question.

Prerequisite: Condensed matter lecture required.

44. Diamond Quantum Sensors

P. Maletinsky

2 students per course



Quantum sensing uses controlled quantum states to detect weak signals beyond the reach of conventional measurement techniques. Diamond nitrogen-vacancy (NV) centers are versatile solid-state quantum sensors that combine optical readout, coherent microwave control, and high sensitivity. In this block course, students will be introduced to the physics of the NV center and gain hands-on experience with confocal microscopy, optically detected magnetic resonance, and coherent control of the NV spin qubit. The course will first offer an introduction to basic experimental techniques in confocal microscopy and optical spectroscopy; its core part will then focus on characterizing an NV sensor and benchmarking the confocal microscopy setup, for example by determining the spatial resolution, Rabi frequency, and dominant noise sources. A second focus will be the fabrication of NV sensors, with particular emphasis on diamond nanostructures such as nanopillars used in scanning-probe experiments. In such experiments, the NV spin is scanned across a sample to image local magnetic fields or other physical quantities with nanoscale resolution.

Depending on laboratory availability and student interests, the course may also connect to ongoing research projects in the group, such as applying NV sensors to novel magnetic materials or developing diamond-based scanning probes with new functionalities.

B. 1 Woche ganztägig, in der vorlesungsfreien Zeit, 3 KP pro Kurs

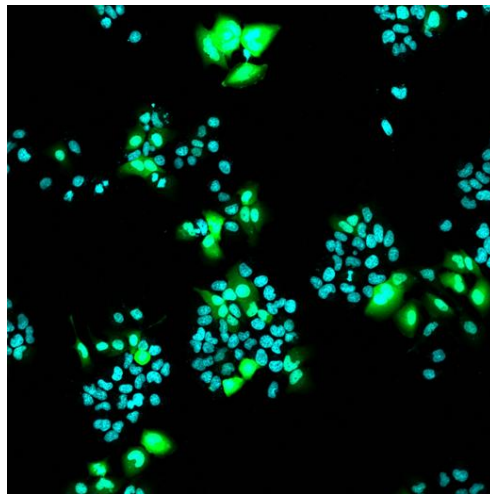
Für die Intensivkurse müssen Sie neben der einen Woche Kurs zusätzlich Zeit für die Vorbereitung und für den Bericht einplanen.

Department of Pharmaceutical Sciences, Pharmaceutical Technology, Unibas

28. Optimization of lipid nanoparticles for gene delivery

J. Huwylér

Pro Kurs max. 2 Studierende, min. 1



DNA lipid nanoparticles (LNPs) are a promising gene delivery system that uses a combination of DNA and lipids to create small, stable particles capable of efficiently delivering genetic material into cells. LNPs are typically composed of a cationic lipid, which binds to the negatively charged DNA, and a neutral lipid, which helps stabilize the nanoparticle structure. The resulting LNPs are able to protect the DNA from degradation and facilitate its uptake into cells, where it can be transcribed and translated into proteins. LNPs have shown potential as a gene therapy tool for a variety of diseases, including cancer, genetic disorders, and viral infections.

The one-week practical training intensive course primarily centers on the preparation of lipid nanoparticles and the transfection of carcinogenic liver cell type HepG2 with genetic material. The production and optimization of lipid nanoparticles will be tested in a screening experiment with HepG2. The curriculum for this internship, which spans a week, includes a series of tasks that will be completed within the given time frame of one week:

- 1) Manufacturing of Lipid Nanoparticles
- 2) Testing the different composition of lipids
- 3) Cellular uptake and transfection efficiency by *in vitro* testing of carcinogenic liver cells
- 4) Cell viability measurements with MTS method
- 5) Data evaluation and discussion of optimization strategies

The one-week course program aims to familiarize students with non-viral gene delivery and to learn diverse strategies for evaluating lipid nanoparticle formulations. In the process, students

will prepare lipid nanoparticles that contain DNA as cargo using microfluidics. Various lipid particles with distinct physicochemical characteristics will be studied using dynamic light scattering, *in vitro* assays involving HepG2 cells, flow cytometry (FACS), confocal microscopy, and assays to quantitatively measure cellular uptake and transfection efficacy. Cell viability will be assessed using the MTS assay.

The students will get a first insight into the theory and practical application of LNPs for gene delivery. They will manufacture LNPs and use them to transfect liver-derived cells.

Goals of the Course:

- The students are familiar with non-viral gene delivery methods using LNPs to transfect carcinogenic liver cells.
- The students are familiar with manufacturing of LNPs and know how to characterize them using different analytical methods.
- The students know how to measure cellular uptake and transfection efficacy using flow cytometry and confocal microscopy.
- The students know how to determine cell viability with *in vitro* methods (MTS)

18. Surface modification and nanosensors

J. Köser FHNW (1 week intensive course)
Pro Kurs Max. 8 Studierende, Min. 4

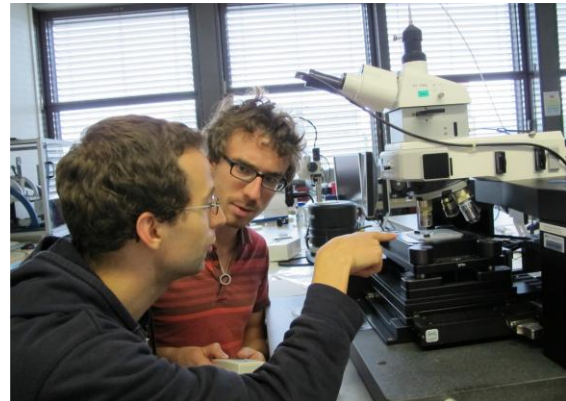
The one-week practical training intensive course focuses mainly on biosensing technologies. The students will get a broad introduction into the theory and practical application of modern sensing technologies. The practicum includes the activation and functionalization of sensors and study of (bio-)molecule interactions. The course is composed of the following tasks which have to be addressed during this one week practical training:

- 1) Gold-NP synthesis for sensor applications
- 2) Sensor surface cleaning and activation
- 3) Chemical functionalization of surfaces and immobilization techniques to couple biomolecules to functional surfaces
- 4) Applications in biosensing: e.g. a) quartz crystal microbalance, b) biolayer interferometry, c) lateral flow assay, d) biomolecular affinity measurements

The one week course will introduce the students to most recent methods for surface functionalization of common sensing platform materials e.g. glass, silicon or gold on glass. The students will learn about the very critical issue of surface cleaning and the effect on surface functionalization and will perform silanization reactions, self assembled monolayers based on thiol chemistry, layer by layer coating and functionalization by chemical bonding.

In the context of surface modifications the influence of surface chemistries, topography resp. material properties on the specificity and activity of immobilized or

interacting biomolecules will be critically discussed. In the area of biosensing surface effects can influence the specificity and functionality of the immobilized biomolecules. This could lead to wrong or deviating results depending on the sensing systems used and has to be considered comparing results from different sensing technologies.



The course is structured in separate experiments exemplifying functionalization and (bio-)sensing techniques and applications, i.e. “layer-by-Layer” functionalization and quartz crystal microbalance based mass sensing, chemical activation, covalent biomolecule functionalization and biolayer interferometry for biomolecular affinity measurements as well as nanoparticle synthesis, functionalization and application for lateral flow assays.

19. Functional biocompatible materials for medical applications

J. Köser, M.de Wild
FHNW (1 week intensive course)
Pro Kurs Max. 8 Studierende, Min. 4

The one week practical training intensive course focuses mainly on biocompatible materials used in medical applications. This includes preparation and analyzing of the specimen and furthermore the chemical and morphological modification of their

surfaces. The following topics will be covered:

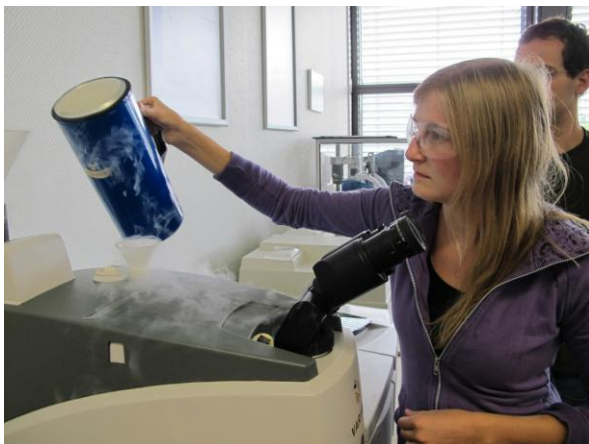
- Morphological modification of material surfaces (e.g. sandblasting, shot-peening, electropolishing and etching)

- Preparation techniques: cutting, embedding, grinding, polishing, and etching (e.g. metals, ceramics, polymers, porous materials, foams)

- Methods for the characterization of biocompatible materials (e.g. morphological, chemical and mechanical) and biocompatibility/cytotoxicity tests

- Chemical functionalization of materials e.g. Al, Si, Ti, Au, Glass, Polymers etc. by various methods.

It is of outermost importance and prerequisite to know the bulk microstructure, the microstructural constituents, the static and dynamic mechanical properties and the surface morphology and chemical composition of biocompatible materials when using it in a medical device or other medical applications. This knowledge is requested by the authorities to guarantee the materials quality and avoidance of unwanted side effects when the materials come into contact with human tissue or body fluids. During the one week practical training course the students will be introduced to most recent methods for biomaterial modification and characterization.



The students will learn how to prepare the different materials e.g. titanium or ceramics for the morphological, mechanical and chemical composition analysis. The students will be trained to embed, cut and polish the specimens in order to investigate e.g. texture, grain size, layer thickness and roughness. To investigate topographical features the students will be introduced to advanced microscopic technologies like SEM, confocal microscopy, polarising microscopy and others. The chemical composition will be determined by spectroscopic methods e.g. ToF-SIMS, EDX, IR or Raman Imaging. Furthermore static and dynamic mechanical properties will be determined by tensile measurements as well as fatigue testing on a e.g. servo-hydraulic system. Critical issues like surface energies measured by tensiometry and contact angle will be addressed and their importance discussed in the view of the medical application of the material e.g. wetting of titanium with body fluids. In addition to the sample preparation and material characterisation, the students will learn in various practical exercises how to chemically activate, coat, functionalize, passivate or mechanically/chemically structure the materials surfaces and study the impact on the materials characteristics and their behaviour in biological environments (Body fluids e.g. blood or cell cultures).

In the frame of the course the students will follow the entire industrial development chain of biocompatible materials used in medical applications.

Goals of the course:

- The students are familiar with the most common methods to prepare specimen e.g. implants for materials investigations

- The students are familiar with modern methods for materials characterization with

respect to both, the chemical composition and mechanical properties of the bulk material and the surface

-The students will have an overview of the most state of the art methods to chemically and physically modify surfaces of biocompatible materials.

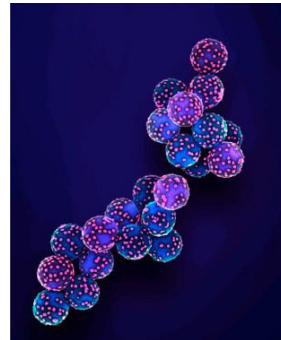
-The students will gain insight in the analytical methods allowing the biocompatibility assessment of biomaterials.

-The students are aware about the importance of the interface of materials and the biological environment for their proper function in the medical applications.

31. Engineered functional nanoparticles

Patrick Shahgaldian FHNW

Pro Kurs max. 4 students



Engineered functional nanoparticles find applications in an exponentially increasing number of industrial sectors. As the surface physico-chemical characteristics of nanoparticles mostly dictate their general behavior and performance, the development of methods to chemical or physically modify the surface of nanoparticles is a foremost research focus in nanotechnology. In this Blockcourse, you will have a first hands-on experience on how to handle and chemically modify the surface of inorganic oxide nanoparticles for two distinct applications:

- 1) Chemical nanostructuration of the surface of silica nanoparticles, to yield nanomaterials with protein recognition properties
- 2) Functionalization of silica nanoparticles to produce efficient enzyme-based nanobiocatalysts

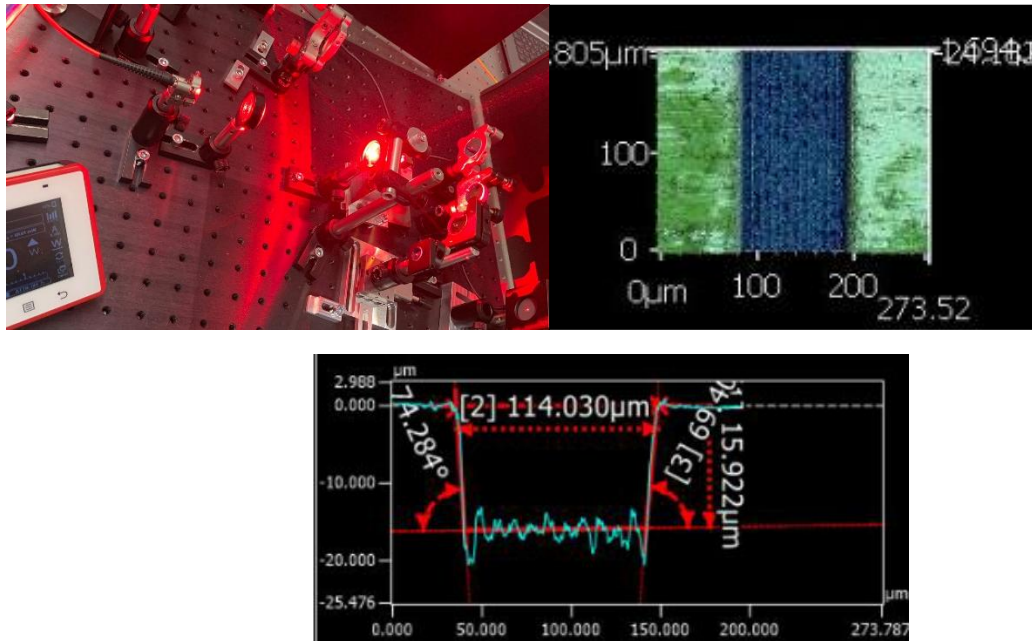
This blockcourse, along with theoretical highlights, will involve a body of synthetic and analytical work. The produced nanoparticles will be analyzed using state-of-the-art electron microscopy methods, scanning probe microscopy and photon correlation spectroscopy. The functional properties of the produced nanosystems will also be assessed using spectrophotometric and/or immunological method

36. Femtosecond lasers, optical microscopy and Optical Coherence Tomography

Bojan Resan

FHNW School of Engineering and Environment, Institute for Product and Production Engineering

Pro Kurs 4 Students



Today, the main light source for optical microscopy is a laser, and for advanced methods a femtosecond (ultrafast) laser is required. Therefore, to understand the capabilities and limitations of optical microscopy, we will start with introduction to laser, followed by description of main concepts of femtosecond lasers. In the third lecture we will explain the general aspects and terminology of an optical imaging system. The fourth lecture will cover the confocal (linear) and multiphoton (non-linear) microscopy. In the last lecture we will describe the novel (recent Nobel Price winning) super-resolution microscopy and Optical Coherence Tomography.

The course is 5 days, divided into 2-3 theoretical lectures in the morning, followed by 3-5 hours of practical exercises in the afternoon, where the students will work hands-on and measure various parameters of lasers and microscopes.

The goal is that after this course students understand the principles of laser, femtosecond laser, and general imaging system; and they can decide if confocal, multiphoton, or super-resolution microscope is suitable for their needs and budget.

16. Doppelblockkurs Funktionale Oberflächen und Materialien am Paul Scherrer Institut

A. Oechsle, Ch. Wäckerlin, M. Muntwiler, T.A. Jung

Max. 6 Studierende pro Semester



Voraussetzungen: Interesse für NanoChemie/Physik und Oberflächen/Grenzflächen; disziplinenübergreifende Forschung.

Veranstaltungsort: Paul Scherrer Institut, Villigen PSI, <https://www.psi.ch/en/lxn/molecular-nanoscience>

Projektbeschreibung:

Sie werden in die Spektro-Mikroskopie-Korrelation eingeführt, das heisst Sie gewinnen sowohl mikro- (eigentlich nano-)oskopische Informationen über die Anordnung und die Eigenschaften von Atomen und Molekülen in Nanostrukturen an Oberflächen als auch spektroskopische Information aus mittelnden photoelektronenspektroskopischen Experimenten. So identifizieren Sie zum Beispiel die Art und Besetzung der Orbitale und die räumliche Verteilung der Elektronenzustände.

Anhand eines konkreten Projektes mit Bezug zu einem aktuellen Forschungsthema der Forschungsgruppe wird zunehmend selbständig mit Präparationstechniken, Instrumenten und Charakterisierungstechniken gearbeitet. Einkristalloberflächen werden atomar sauber präpariert, mit Elektronendiffraktion (engl. LEED), und Oberflächenspektroskopie (engl. XPS, UPS) charakterisiert und mit ultradünnen Materialschichten (Molekulare Materialien /Isolatoren) bedeckt. Mit dem Rastertunnelmikroskop oder dem Rasterkraftmikroskop werden die so erzeugten Oberflächen abgebildet und die Daten analysiert und interpretiert.

Am PSI sind Doppelblockkurse unter Einbezug des Synchrotrons möglich. (UV und Röntgen Photoelektronenspektroskopie, Röntgenabsorptionsspektroskopie (engl. UPS, XPS, XAS) an der “Swiss Light Source” zusammen mit Rastertunnelmikroskopie (engl. STM) oder Rasterkraft-mikroskopie (engl. SFM) im Labor. Diese Projekte müssen individuell abgesprochen werden.

Wichtige Anwendungsgebiete der Nano-/Oberflächenwissenschaften konstituieren sich z.B. in der Halbleitertechnik, den Materialwissenschaften und der Katalyse. Bei entsprechendem Interesse können auch Projekte in Zusammenarbeit mit Firmen wie Roche, Glas Trösch, und Hitachi Energy bearbeitet werden.

Für den Bericht soll unter Anleitung und selbständig nach weiterführenden Beiträgen in der aktuellen wissenschaftlichen Literatur gesucht werden. Anhand dieser Referenzen sollen die verfügbaren Daten interpretiert und diskutiert werden.

Planungsinformationen:

Doppelblockkurs, 2 Wochen Vollzeit, Unterkunft im PSI-Gästehaus oder Hotel.

~2 Studierende pro Block, maximal 6 Studierende pro Semester; Zeitfenster nach Absprache, auch während der Semesterferien möglich.

Weitere Informationen / typische Projekte / Stellenausschreibungen:

<https://www.psi.ch/en/lxn/molecular-nanoscience#news-and-highlights>

e-mail: thomas.jung@psi.ch

22. Neutron scattering in solid state physics: diffraction, spectroscopy and reflectometry

M. Kenzelmann, L. Keller



Location: Paul Scherrer Institute,
Villigen PSI, <http://www.psi.ch/Ins>
Prerequisite: Solid State Physics

Min: 2 Students Max: 4

In this 5 day intensive course at the Swiss spallation neutron source SINQ [1] you will learn the basic principles of three different neutron scattering techniques and their applications in solid state physics: neutron diffraction, small angle neutron scattering and neutron reflectometry [2].

- Magnetism is omnipresent in condensed matter physics. In this practical course you

will learn how to perform a neutron powder diffraction experiment, apply all the necessary corrections, as well as to analyze the data in order to determine the chemical and the magnetic structure of crystalline materials. In particular, you will reproduce the experiment that led to the Nobel prize awarded to C.G. Shull in 1994.

- Soft matter is used in many aspects of life, for example in food and health care. Small angle neutron scattering (SANS) allows to gain access to structures much larger than the neutron wavelength, which typically lies in the range from 1 Å up to 20 Å. SANS is thus used to probe features with a typical size in the range from 1 nm up to 150 nm in all kinds of materials including soft matter.

In your experiment you'll study one such example and observe the micellization of a surfactant.

- Two dimensional materials is an important class of materials that is heavily study for their fundamentally novel properties. Often, such materials are made as thin films or multilayers. Neutron reflectometry is a powerful tool to investigate the depth dependence of layered materials. You will apply this method to alternating layers of Ni and Ti on a glass substrate and determine the properties of the periodic nature of these multilayers.

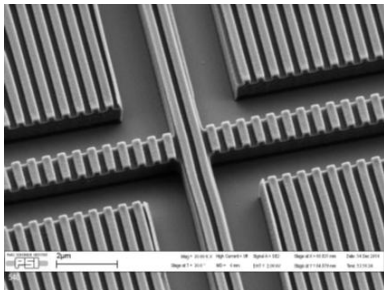
[1] <http://www.psi.ch/sinq>

[2] Andrew T. Boothroyd, "Principles of Neutron Scattering from Condensed Matter", Oxford University Press, Higher Education (2020)

23. Micro- and nanofabrication of surface topographies

H. Schiff

1 week intensive laboratory course
max. 4 Studierende (mind. 3)



No matter, in which field of nanotechnology (nanoelectronics, medical devices, sensors, scanning-probe instrumentation etc.) the students will specialize later on, it is very likely that they will be confronted with problems of top-down microfabrication since the nanodevices, -structures or -components are very often embedded in a microfabricated environment. This one-week intensive laboratory course therefore focusses on top-down micro- and nanofabrication technologies in a state-of-the-art clean room environment. The small group of students

will be accompanied by an instructor (a process technician or an engineer).

The following topics will be treated during the course:

- Introductory lecture on cleanroom operation, and laboratory safety;
- Thin film technologies: metal evaporation, surface modification, resist spin-coating;
- Pattern definition by photolithography, electron beam lithography, EUV interference lithography;
- Pattern transfer: wet and dry etching, resist stripping, lift-off;
- Replication techniques of topological structures using nanoimprint lithography (thermal and UV-imprint);
- Quality control and characterization: optical and scanning electron microscopy, surface profiling.

In this course the students will get acquainted with the most important processes in micro- and nanofabrication, including new lithographic techniques such as nanoimprint lithography. The students will take home different topological and chemical structures for further characterization.

Goals of this course are:

- Get hands-on experience with the most important microfabrication technologies,
- Understand the basics and the mechanisms of microfabrication processes,
- Learn how to properly work in a professional clean room environment.

Further information:

<https://www.psi.ch/en/lnq>

Dr. H. Schiff, Paul Scherrer Institut

Tel.: 056 310 28 39

helmut.schift@psi.

26. μ SR spectroscopy of magnetic and superconducting materials

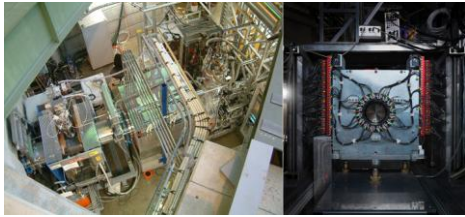
H, Luetkens, T. Prokscha

Prerequisite: Solid State Physics

1 Woche Intensivkurs

Minimum 2, Maximum 4

Location: Paul Scherrer Institut, Villigen
PSI, <https://www.psi.ch/lmu>



Learn the basic principles of muon spin rotation and relaxation techniques (μ SR) and use the method to obtain local information about magnetic and superconducting properties of novel superconductors.

This practical course allows learning how a μ SR experiment is performed and analysed. It gives detailed insight into a modern local probe technique of condensed matter research making use of a particle beam at a large scale facility such as PSI. In order to do so, you will cool down the sample to a few Kelvin temperatures with a Helium flow cryostat. With the guidance of an instrument scientist, you will run and analyze the experiment using our computerized experimental control and data acquisition system.

The experiment is performed at the General Purpose Spectrometer μ SR beam line (GPS,

<https://www.psi.ch/en/smug/gps>) and at the Low Energy Muon beam line (LEM, <https://www.psi.ch/en/smug/lem>).

Actual research topics of members of the Laboratory of Muon Spin Spectroscopy are chosen for the practicals. These comprise contemporary condensed matter physics questions such as:

- Microscopic study of topical magnetic or superconducting materials. Determination of magnetic phase diagrams, static and dynamic magnetic properties as well the investigation of symmetry and length scales in the vortex state of type-II superconductors.
- Direct measurement of the magnetic field profile on a nm scale and direct determination of the magnetic penetration depth at the surface of a high T_c superconductor (T.J. Jackson, *Phys. Rev. Lett.* **84**, 4958 (2000); R.F. Kiefl, *Phys. Rev.* **B 81**, 180502(2010); R.M.L. McFadden, *Phys. Rev.* B113, L060508 (2026)).

Literature:

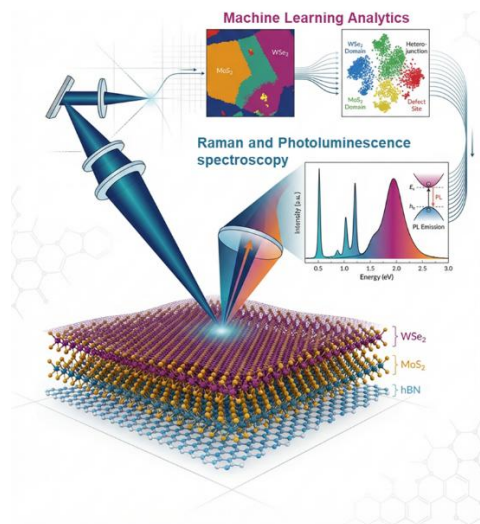
A. Amato, Lecture Course at U Zurich “Physics with Muons: from Atomic Physics to Condensed Matter Physics”, <https://www.psi.ch/en/media/73526/download>

40. Raman, photoluminescence and machine learning analytics at the nanoscale

Angel Labordet, Guanting Guo, Mirjana Dimitrievska, Michel Calame

Location: Empa, Ueberlandstrasse 129, 8600 Dübendorf

Min. 2, max. 3 Students



Low-dimensional materials are promising building blocks for future electronic and quantum devices. Raman, photoluminescence (PL) and time-resolved photoluminescence (TRPL) spectroscopy are powerful tools to probe their structural and optoelectronic properties.

In this course, students will learn the basic principles of these techniques and their application to 1D and 2D materials such as graphene nanoribbons, graphene mono- and bilayers, and transition-metal dichalcogenides. The course will also introduce modern data analytics for optical spectroscopy, including preprocessing, multivariate analysis and machine-learning-assisted methods for spectral classification and hyperspectral mapping.

Further Information:

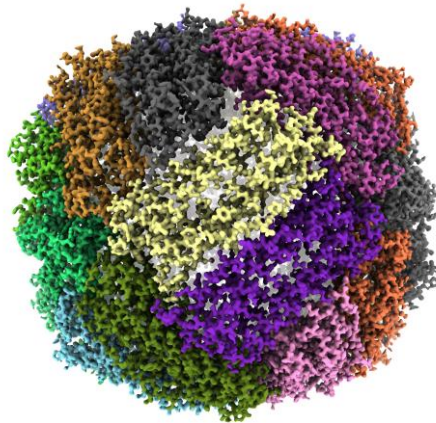
Dr. Mirjana Dimitrievska, Prof. Dr. Michel Calame

<https://www.empa.ch/tnilab>

39. Structure determination of protein complexes by cryo-transmission electron microscopy and image processing

Henning Stahlberg

3 Students



Apoferritin is a widely used test specimen for cryo-EM. It is highly stable and has a 24-fold symmetry. The structure of Apoferritin was resolved by conventional cryo-EM at the Dubochet Center for Imaging in Lausanne at a resolution of 1.09 Å <https://www.ebi.ac.uk/emdb/EMD-19436>

This one-week intensive block course will take place in the Laboratory of Biological Electron Microscopy (LBEM) in the Physics institute of the EPFL in Lausanne, Switzerland. In the LBEM, our group is using electron microscopy to understand the structural mechanisms underlying neurodegeneration. We study several membrane protein and soluble protein systems that play a role in diseases such as Parkinson's disease or Alzheimer's disease. For this, we purify in the lab the proteins, study their structure by cryo-electron microscopy (cryo-EM) and image analysis, and interpret these structures in the context of structural studies of human brain tissue from patients suffering from neurodegeneration. For this, the lab has access to the frontier equipment of the Dubochet Center for Imaging, which is a facility in our institute that offers cryo-EM at highest resolution to customers. The LBEM is also developing novel approaches to electron microscopy, using stroboscopic electron illumination or coherent electron diffractive imaging, for which the LBEM operates its own electron microscopes.

In this block-course, the students will participate in the structural analysis of a protein complex. Students will purify proteins, prepare these for electron microscopy investigations as negatively stained preparations or as frozen hydrated thin films, screen samples by themselves on transmission electron microscopes, participate in the high-resolution data collection with the high-end cryo-EM instruments of the Dubochet Center for Imaging in Lausanne (including a 300kV Titan Krios with latest features), and perform computational image analysis for obtaining a 3D reconstruction of the protein structures.