# Blockkurse Nanowissenschaften UniBS (total 24 CP)

## Inhaltsverzeichnis

# A. Module von 3 Wochen, nachmittags, 3 CP pro Kurs.

### 1. Messen, Regeln, Steuern

E. Meyer
10 Studierende, (mind.6)

Modernste Messmethoden, wie sie in der aktuellen Forschung verwendet werden, sollen erklärt werden und im Labor mit Hilfe von elektronischen Bauteilen und der Software LABVIEW angewendet werden. Anwendungen aus der Klassischen Physik und der Festkörperphysik werden diskutiert. Der Inhalt umfasst folgende Themen: Sensoren, Elektronische Halbleiter-Bausteine, Aktivatoren, Elektronische (analoge) Datenverarbeitung: OpAmp, Filter, Messung kleiner Signale, DACs und ADCs, Regelkreise, Lock-In Technik, Real-Time Daten-Analyse. Der Stoff wird schrittweise aufgebaut. Lösungen aus vorangehenden Übungen werden später jeweils wieder verwendet.

Falls der Kurs wegen mangelnder Teilnehmerzahl nicht durchgeführt wird, werden die angemeldeten Studierenden auf die freien Plätze der anderen Kurse verteilt.

### 2. AFM in Biologie

D.Müller
4 Students, (mind. 2 )

Goal of this course is to become acquainted with performing AFM experiments on biological samples. During the course the students work in groups of maximal 3 students on three different applications. These applications partly originate from current research topics in the group.
Last year, two of the applications dealt with imaging and manipulation of membrane proteins in buffer solution. The buffer solution is the (near) native environment of most proteins and allows adjustment of conditions to obtain high resolution images. One part deals with high resolution imaging of membrane proteins in contact mode (in liquid). The students learn the critical parameters in sample preparation and imaging conditions. The second part deals with force spectroscopy, i.e. unfolding, (membrane) proteins. Membrane proteins generally unfold stepwise, allowing the calculate at which position stabilizing entities exist in the protein. This can assist in finding amino-acids that are import for the structure and/or functioning of the protein. Students will learn how to carry out such unfolding experiments, and how to process the data. In the last application fixed bacteria were imaged. Students prepared own samples by fixation of bacteria during their exponential growth phase. In addition, it similarly prepared bacteria treated with antibiotics were imaged. In this application a different imaging mode is used: Tapping mode in air. With the AFM images placed on top of an optical microscope, correlation between AFM and optical images is possible. By rotation, all students will work on each of the applications.

### 3. Quantum Coherence Lab

D.Zumbühl

#### 3.1. Messkurs:

es kann aus einer Auswahl von drei verschiedenen Experimenten ausgewaehlt werden, insgesamt max. 3 Personen (min. 2 Personen). KoMa und QM erwünscht:

- ***Quantum Point Contacts (nano physics experiment, groups of min. 2, max. 3 persons*)**

What happens to the electrical conductance of a wire if its width is reduced from macroscopic dimensions to nano scale sizes? The conductance of a macroscopic wire is proportional to its width. However, if the width becomes small enough, quantum physics will become dominant. The conductance is then no longer proportional to the width of the wire, instead the conductance is quantized in multiples of the quantum of conductance. In magnetic fields, consequences of the electron spin on the wire conductance can also become apparent.

A quantum point contact is an example of such a narrow nanoscale wire where quantum effects become dominant. We will either provide an appropriate sample, or, in the GaAs nano lithography course, you may participate in the fabrication of such a device on a GaAs 2D electron gas using nano-patterened surface gate structures. In order to observe quantum effects, low temperatures are often required.

**In this course**, you will study electrical transport properties of a quantum wire and investigate the quantum physics of this nano scale device and how it depends on magnetic fields, temperature and applied voltage. In order to do so, you will work with a dilution refrigerator to cool down a GaAs quantum point contact device to millikelvin temperatures. With the guidance of a teaching assistant, you will run the experiment using our computerized experimental control and data acquisition system. Recommended (but not necessary) prerequisite is the GaAs nano lithography course. This experiment is best conducted in groups of 2 to 3 persons.

- ***Quantum Dots (nano physics experiment, groups of min. 2, max. 3 persons)***

A quantum dot is a nano scale object on which a small number of electrons can be confined in all three spatial dimensions, with the possibility of attaching leads for measuring an electron current through the dot. Because of the nano scale size, the behavior of the dot is radically different from macroscopic objects, displaying quantum mechanical effects such as discrete energy levels (size quantization) as well as classical charging effects (Coulomb Blockade). The electron spin can also be important in transport through quantum dots (e.g. Kondo effect).

We will either provide an appropriate quantum dot sample, or, in the GaAs nano lithography course, you may participate in fabrication of such a device on a GaAs 2D electron gas using nano patterned surface gate structures. These hallmark effects of nano scale physics are best observed at millikelvin temperatures.

**In this course**, you will investigate electrical transport properties of quantum dots and investigate the quantum physics of this nano scale device and how it depends on magnetic fields, temperature and applied voltage. In order to do so, you will work with a dilution refrigerator to cool down a GaAs quantum dot to millikelvin temperatures. With the guidance of a teaching assistant, you will run the experiment using our computerized experimental control and data acquisition system. Recommended (but not necessary) prerequisite is the GaAs nano lithography Course. This experiment is best conducted in groups of 2 to 3 persons.

- **Integer/Fractional Quantum Hall Effect** ***(nano physics exp., groups of min. 2, max. 3 pers.)***

Take a gas of electrons confined in a nano scale 2D layer in an appropriate material and apply a strong magnetic field perpendicular to the 2D plane. Classically, due to the Lorentz Force, the electrons move in circles in the 2D plane. Quantum mechanically, however, in clean enough samples at low enough temperatures, this results in the integer and fractional quantum Hall effects, which are manifest in measurable electrical properties such as plateaus at integer or fractional multiples of the conductance quantum $e^2/h$ (see Nobel prizes 1985 (integer effect) and 1998 (fractional effect)).

**In this course**, you will study integer and fractional quantum hall effects using electrical transport measurements. In order to do so, you will work with a dilution refrigerator to cool down a GaAs 2D electron gas Hall bar to millikelvin temperatures. With the guidance of a teaching assistant, you will run the experiment using our computerized experimental control and data acquisition system. This experiment is best conducted in groups of 2 to 3 persons.

**3.2 GaAs Nano Fabrication** ***(groups of min. 2, max. 3 persons)***

GaAs materials and 2D electron gases and transistors are in use today in various commercial applications, for example high frequency amplifiers, and are also of great interest for fundamental nano scale physics research. Therefore, fabrication of GaAs nano scale structures is of great importance, and the goal of this course is to teach fundamental techniques for nano fabrication on GaAs and give a hands-on experience by making some simple GaAs nano structures. The standard techniques include III-V compound etching, optical lithography, resist spinning and developing methods and may also include electron beam lithography on GaAs wafers. You may either participate in fabrication of ongoing research projects or participate in fabrication of a nano structure to be used for one of the nano physics blockcourses (quantum point contacts, quantum dots, quantum hall effect).

**4. Methods in Nanobiology**

R.Lim

12 Studierende

In this Blockkurs we will employ the AFM and optical devices to image, measure and manipulate biological matter from the nm to the mm scale. Specimens will include cytoskeletal filaments, molecular machines, cultured cells, and various tissues. Among others, we will watch molecular machines at work, measure the mechanical properties of vascular tissue and articular cartilage, and mechanically puncture cells and follow their healing.

**5. Self-assembling polymers**

W. Meier

12 Studierende

Amphiphile Blockcopolymere bilden in Wasser selbstorganisierte Überstrukturen mit charakteristischen Dimensionen im Nanometerbereich. Aufgrund ihrer charakteristischen Überstrukturen finden sie Anwendung als neue funktionale Materialien mit aussergewöhnlichen Eigenschaften, oder als Template zur kontrollierten Herstellung organischer und anorganischer Nanopartikel. Im Rahmen des Blockkurses sollen solche Systeme kontrolliert hergestellt und mit verschiedenen Techniken charakterisiert werden.

6. **Nanolithographie**

Ch. Schönenberger

Max. 3 Studierende

Integrierte Schaltkreise (sog. IC's) werden mittels Lithographieverfahren in Silizium gefertigt. Strukturen (z.B. metallische Leiterbahnen, Transistoren) werden mit Abmessungen im Submikrometerbereich gefertigt (Nanolithographie). In der Forschung versuchen wir, möglichst

kleine Strukturen an der Grenze des Machbaren zu erzeugen und deren Eigenschaften zu charakterisieren. Dieser Kurs soll einen Einblick in diese Strukturverfahren vermitteln.
Es wird versucht, Sie während den drei Wochen in ein laufendes Projekt zu integrieren. Dabei werden Sie mit folgenden Verfahren (Apparaturen) in Berührung kommen: Belackung von Si-Substraten; Bestimmung der Schichtdicke; optische- und/oder Elektronenstrahl-Lithographie; Plasmaätzen (subtraktives Verfahren); Aufdampfen von Metallschichten und lift-off Prozess (additives Verfahren); Rasterelektronenmikroskopie.
Voraussetzungen: Der vorgängige Besuch des Mikroskopiekurses ist wünschenswert.

**7. Nanophysics: Low-dimensional conductors**
**Ch. Schönenberger**
Max. 3 Studierende

Ein klassischer Kupferdraht ist für die Elektronen, die für den Ladungstransport sorgen, etwas Dreidimensionales. Wenn der Draht kleiner und kleiner wird, findet ein Übergang in der Dimensionalität statt. Es gibt dann 2-dimensionale und eindimensionale Drähte und im Prinzip sogar null-dimensionale Systeme. In diesem Blockkurs legen wir den Schwerpunkt auf niedrig-dimensionale Materialien, die in neuartigen Wachstumsverfahren gewonnen werden, wie z.B. Kohlenstoff-Nanoröhrchen, halbleitende Nanodrähte oder Graphene (eine Monoschicht von Graphite). Bei den Kohlenstoff Nanoröhrchen haben die kleinsten einen Durchmesser von nur einem Nanometer und können dennoch in makroskopischer Länge gewachsen werden. Diese Röhren weisen beeindruckende Eigenschaften auf: mechanisch sind sie vergleichbar widerstandsfähig wie Diamant; elektrisch können sie den Strom leiten wie kein anderer Draht mit vergleichbaren Abmessungen.
Abhängig von den gerade bestehenden Forschungsaktivitäten wird das Ziel des Kurses jedes Jahr neu fixiert. Wir werden versuchen, eine aktuelle Fragestellung zu bearbeiten.
Voraussetzung:
Kondensierte Materie / Mikroskopiekurs empfohlen / Nanolithographie vorgängig wird empfohlen

**8. Molecular Physics**
Ch. Schönenberger
Max. 3 Studierende

Molecules are used in a variety in various applications in the field of opto-electronics. For example, liquid-crystal displays, organic LEDs, e-paper, organic solar cells, batteries etc. Whereas molecules have been studied in the form of polymers for many years, the harvesting of functions embodied in a single molecule is still outstanding. We, and other, strive to understand charge transport in single and a few molecules. Different techniques are applied: on the one hand, we use the so-called mechanically controlled break junction to contact single molecules. On the other hand, networks of Au colloids are used as a platform to explore the conductivity of molecularly interlinked colloids. Furthermore, electromigration of small Au contacts can be used to generate small gaps in which molecules can be trapped. We also use electrochemical techniques to characterize molecules in solution. We will define a project in this field of research that is interlinked with ongoing research.
Voraussetzung:
Kondensierte Materie / Mikroskopiekurs empfohlen

**9. Scanning Probe Microscopy**
E. Meyer
6 Studierende

Im ersten Teil wird ein STM (scanning tunneling microscope) selbst gebaut und in Betrieb genommen (Bau eines Vorverstärkers, Zusammenbau der Mechanik, Verdrahtung). Ziel ist es stabile Tunnelstrom-Bedingungen zu erreichen und einige Proben an Luft zu messen. Im zweiten Teil wird das AFM (atomic force microscope) an Luft in Betrieb genommen. Es werden die verschiedenen Messmoden (contact mode, tapping mode, nc-AFM, Kelvin) betrieben. Schliesslich wird eine Einführung in die Vakuumtechnik mit praktischen Experimenten gegeben (Druckmessung, Pumpsysteme, Dichtungen). In der letzten Woche wird am UHV-AFM (ultrahigh vacuum atomic force microscope) eine Messung an einer isolierenden Oberfläche durchgeführt.

**10. Mikroskopie**
M. Dürrenberger
12 Studierende

Wir möchten Ihnen die Abbildung der Mikro- und Nanowelt vermitteln. Sie erhalten eine Grundausbildung in Lichtmikroskopie, Transmissionselektronenmikroskopie und Rasterelektronen-mikroskopie. Anschliessend werden Sie in Zweiergruppen ein Rasterelektronenmikroskop selbständig betreiben. Dies beinhaltet Präparation, die Bedienung des Gerätes und Analyse der Präparate. Ihre Fähigkeiten werden mit einer abschliessenden schriftlichen Arbeit geprüft (wird benotet).
*Zur Beachtung:* Dieser Kurs wird als Vorbildung zum Kurs Nr. 7 „Nanophysics“ empfohlen.

**11. Nanomaterialien und Elektronenspektroskopie**
E.Meyer/ Laurent Marot
Max. 2 Studierende

Im Rahmen dieses Blockkurses werden plasmagestützte Techniken angewendet, um nanostrukturierte Materialien herzustellen. Die abgeschiedenen Materialien werden in-situ bezüglich ihrer Zusammensetzung und ihres chemischen Aufbaus mit Photoelektronenspektroskopie (PES) charakterisiert.

**Kursthemen:**
*Schichtabscheidung:*
Methoden der vakuumgestützten Schichtabscheidung, plasmagestützte CVD ('chemical vapor deposition') Abscheidung, Magnetronsputtering, kombinierte Methoden zur Herstellung nanostrukturierter Materialien, Ausblick auf andere Schichtabscheidungsmethoden.
*Prozessüberwachung:*
in-situ, 'real-time' Überwachung der Schichtabscheidung mit Reflektometrie.
*Allgemeine Schichtcharakterisierung:*
Schichtdickenmessung durch Profilometrie und Vergleich mit optischen Methoden, Untersuchung der Schichttopographie mit Rasterelektronenmikroskopie und Rastersensormethoden.
*Photoelektronenspektroskopie:*
allgemeine Grundlagen der PES (Mechanismus, einfache Modelle, Anwendung der PES), Bestimmung der chemischen Zusammensetzung von Schichten mit in-situ Röntgen-Photoelektronenspektroskopie (XPS) und Ultraviolett-Photoelektronenspektroskopie (UPS), Identifizierung von chemischen Bindungen, Methoden zur Bestimmung der Nanostruktur von Nanokompositmaterialien.

**12.Atomistische Simulationen**
M. Meuwly
6 Studierende

Dieser Blockkurs gibt Einblick in die Durchfuehrung und Analyse von Molekular-Dynamik Simulationen mit spezifischen Anwendungen auf Fragestellungen der kondensierten Materie. Moegliche Themen beinhalten die Untersuchung von Proton-Transfer Reaktionen, das dynamische Verhalten von Wassermolekuelen in raeumlich einschraenkenden Umgebungen (Proteine, Buckyballs, Nanotubes), oder die Bestimmung des Infrarot Spektrums von kleinen Liganden in Myoglobin. Fuer 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 zugaengliche Groessen 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) koennen auf Wunsch hin gefunden werden. Programmierkenntnisse sind nicht noetig. Es lassen sich jedoch auch Themen finden, welche explizit die Programmierung in C++, Fortran, perl oder python erfordern. Weitere Informationen und Beispiele aus frueheren Blocckursen finden Sie unter www.chemie.unibas.ch/~meuwly/mdnano.block.html

**13.Nanochemistry**
Marcel Mayor
6 Studierende

The research in the group can be divided in three major parts:
Molecular Electronics
Nano-Objects and –Architectures
New Hybrid Materials
Further informations can be seen on our webpage:
http://www.chemie.unibas.ch/~mayor/research.html
http://www.chemie.unibas.ch/~mayor/research.html
The focus of the course is the design and synthesis of important building blocks for tailor-made molecules.

**14.Algorithmen für atomistische Simulationen**
Stefan Gödecker
6 Studierende

Atomistische Simulationen erlauben es, die Positionen einzelner Atome zu bestimmen und ihre Bewegung zu verfolgen. Mit dieser Information kann eine grosse Anzahl physikalischer und chemischer Eigenschaften berechnet werden. In diesem Blockkurs erhalten die Studenten die Möglichkeit einfache Algorithmen für atomistische Simulationen in einer Programmiersprache (Fortran oder C) zu implementieren und auf ein einfaches Problem anzuwenden. Die theoretischen Grundlagen werden in dem Kurs 'Introduction to computational physics' (VV4505)gegeben.
Das komplette Skriptum dieser Vorlesung finden Sie unter: http://pages.unibas.ch/comphys/comphys/TEACH/WS04/course.pdf

**15. PSI oder Nanolab**
T.A. Jung
2-3 Studierende

**a) Oberflaechenspektroskopie, auch unter Einbezug der ‚Swiss Light Source'**.
T. A. Jung, K. Mueller, Dorota Chylarecka, Nirmalya Ballav

Voraussetzungen: Oberflaechenphysik, Chemie
Veranstaltungsort: Paul Scherrer Institut, Villigen PSI, www.psi.ch

**b) Oberflaechenphysikalische und chemische Methoden zur Erzeugung und Charakterisierung von atomar definierten Nanostrukturen an Oberflaechen.**
M. Stoehr, T. A. Jung,

Voraussetzungen:
Vorbereitungsgespraech / Projektauswahl mit einem der genannten Betreuer
Vorlesung in Oberflaechenphysik, Kenntnisse in organischer Chemie.
Etwa 1-2 Studierende pro Block, maximal 4 Bloecke pro Semester. Zeitfenster nach Absprache, auch in der vorlesungsfreien Zeit moeglich.

Lernziel:
Anhand eines konkreten Projektes mit Bezug zu aktuellen Forschungsthemen wird selbstaendig mit Oberflaechenphysikalischen und Oberflaechenchemischen Praeparationstechniken, Instrumenten und Charakterisierungstechniken gearbeitet.
Einkristalloberflaechen werden atomar sauber praepariert, mit Elektronendiffraktion (engl. LEED), und Oberflaechenspektroskopie (engl. XPS, UPS) charakterisiert und mit ultraduennen Materialschichten (Molekulare Materialien / Isolatoren ) bedeckt.
Mit dem Rastertunnelmikroskop werden die so erzeugten Oberflaechen abgebildet und die Daten analysiert und interpretiert. In Kombination dieser Methoden kann die atomare wie auch die elektronische ‚Struktur' und chemische Koordination von atomen und Molekuelen an Oberflaechen erarbeitet werden. Fuer den Bericht soll unter Anleitung und selbstaendig die aktuelle wissenschaftliche Literatur gesucht werden, und ein fokussierter Aspekt anhand der verfuegbaren Daten interpretiert und diskutiert werden.

Einfuehrende Literatur:
Oberflächenphysik des Festkörpers
Autor: Henzler Martin/ Göpel Wolfgang
Verlag: TEUBNER VERLAG
ISBN: 3519130475

Veranstaltungsort: Nanolab an der Universitaet Basel (erster Keller, Physik Institut)
http://monet.physik.unibas.ch/gue/nanolab/

Blockkurse werden sehr empfohlen zur Evaluation von Masterarbeiten und Dissertationen auf dem Gebiet und im Nanolab. Weitere Informationen / Stellenausschreibungen:
http://monet.physik.unibas.ch/gue/nanolab/

**16. Doppelblockkurse**
In Absprache mit Herrn Jung sind am PSI auch Doppelblockkurse mit Messungen am Synchrotron möglich. Diese Messungen müssen individuell abgesprochen werden.

## B. Module von 1 Woche ganztägig, in der vorlesungsfreien Zeit, 3 CP pro Kurs

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

## Haute Ecole Arc Le Locle

**17. Surface modification and analysis by ion beams (biomedical applications)**
S. Mikhailov CAFI Le Locle (1 week intensive course)
12 Studierende

**Week 1 (HS): Surface micro- nanostructuring and implantation**
Objectives:
To understand the mechanisms of surface modifications using ion beams: micro-, nanostructuring, ion implantation, molecular grafting. Metal and polymers surface functionalization and its application in biosurface engineering and micro technique (smart material).

Content:
-Introduction
- surface definition, ion matter interaction,
- Methods and techniques of ion implantation and deposition
- Applications in biosurface engineering and smart material
- Practical work:
- Ion micro (nano) structuring and implantation
- Ion implantation
- Control

**Week 2 (FS): Surface nano- micro analysis**
Objectives:
To understand the advantages and the limits of ion beam analysis at nanoscale relatively the other methods (XPS, SEM). The applications in biomedicine, implant-tissue interfaces, cell studies.

Content
- Basics of ion beam analysis , methods and techniques
- Rutherford back scattering
- Particle induced x-ray emission
- Applications in material analysis and cell study

-Practical work

- Control

Hinweis: Reisekosten werden gegen Vorlage der Belege erstattet.

## FHNW Muttenz

**18.Surface modification and nanosensors**
U. Pieles FHNW (1 week intensive course)
Maximal 8 Studierende, Minimum 4

The one week practical training intensive course focuses mainly on biosensing technologies. This includes preparation of the active sensors and study of biomolecule interactions The course is composed of the following tasks which have to be addressed during this one week practical training:

1) **Surface Cleaning and Activation**
2) **Chemical functionalisation of Surfaces**
3) **Chemical structuring of surfaces utilizing micro contact printing**
4) **Immobilisation techniques to couple Biomolecules to functional surfaces**
5) **Applications in Biosensing: DNA- Micro Arrays, Surface Plasmon Resonance, Accoustic Wave sensing and Cantilever based Sensor Systems**

The one week course will introduce the students to most recent methods for surface functionalisation of common sensing platform materials e.g. glass, silicon, gold on glass, gold on polymers and polymers itself. The students will learn about the very critical issue of surface cleaning and the effect on surface functionalisation and they will determine residual components on the surface using spectroscopic and microscopic technologies. For surface functionalisation the students will perform silanization reactions, "self assembled monolayers based on thiol chemistry, layer by layer coating and plasma functionalisation. In particular the plasma technology offers a broad variety of possibilities from simple surface cleaning and activation, to depositing complex, functional layers.

The generated layers or functional surfaces will be characterized by various methods e.g. contact angle measurement, determination of surface energy, analysis of the chemical compositions with X-ray spectroscopy or grazing angle infrared spectroscopy. Furthermore microscopic methods like SEM, AFM, Confocal microscopy and others will be used to measure the topography and surface roughness. 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. This is of particular importance for biocompatible materials e.g. implants, artificial bone etc., because of the acceptance by living tissue and the risk of inflammation.
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. This has to be considered comparing results from different sensing technologies.

In addition to surface functionalisation, methods to chemical structure a surface will be trained during the course in theory and practice. As example therefore micro contact printing experiments will be performed. With the casted stamps patterns of fluorescently labelled biomolecules will be transferred to an activated surface and the results will be analysed by fluorescent scanning of the structured surfaces or fluorescence microscopy

The students will get a broad introduction into the theory and practical application of modern sensing technologies. In practical exercises they will make use of the functionalized surfaces and apply them to perform experiments in the area of DNA/RNA micro arrays, cantilever based sensing, SPR and acoustic wave sensing
To couple biomolecules to the surfaces in a structured manner, to measure the results of the

biomolecule interactions and to determine the data, most recent equipment like SPR machines, cantilever sensors, DNA Spotter, Hybstations etc, is available. The students will perform their experiments on most recent technology platforms used today in industry,

Goals of the Course:

- The students are familiar with the most common methods to functionalize surfaces for biosensing applications in theory and practice.

- The students are familiar with the most common methods to characterize the functionalized surfaces and are able to perform surface analysis in practice with technologies e.g. AFM, SEM, Infrared imaging spectroscopy.

- The students will have an overview of the most common methods to chemically structure the surface. They will learn micro contact printing in practical exercises

- The students are familiar with the problem of the influence of surface properties on the activity of biomolecules

- The students will utilize practically the functionalized surfaces in various Biosensing systems. They will get insight in modern biosensing technologies and their applications in the area of Diagnosis, Drug Discovery and fundamental research.

**19. Functional biocompatible materials for medical applications**

U. Pieles FHNW (1 week intensive course)
Maximal 8 Studierende, Minimum 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, 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)
_ 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 characterisation 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 biocopatible 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

## Basel

### 20. A Keldysh Approach to Transport Theory of Nanosystems

L.Chaput aus Mulhouse (1 week intensive course)
12 Persons (min. 2 Persons)

In a bulk material transport is mostly a diffusive process and therefore can be describe with a good approximation using Boltzmann theory. On the contrary, down to the nanoscale, diffusions are less efficient and transport becomes coherent. This is the Landauer approch to transport. Obviously there are intermediate situations where none of the two above theory is applicable. A general formalism is therefore needed. The Keldysh description of transport is such a formalism and allows to describe at the quantum level the non-equilibrium situation provided by any transport experiment. During the lectures the Keldysh Green functions theory will be presented in a form actually used to describe transport experiment. The Meir-Wingreen formula will be prooved and the connexion with Boltzmann and Landauer transport theory will be made. Nano-transport experiment also exhibit some pecularities due to electron-phonons interactions or electronic correlations, such as for example the Coulomb blockade effect. Typical such examples will be worked out during the lectures using the above formalism. Afternoons will be pratical sessions devoted to the STM experiment. Scanneling Tunneling Microscopy is obviously a transport experiment, one of the contact being the surface and the other the tip. The above formalism will be used to work out step by step an analytical/numerical model. Starting from the electronic structure to the current calculation.

## Nanotechnologie Praktikum Neuchâtel NE

### 21.Microfabrication of an Atomic Force Microscope (AFM) Chip

Course dates: August 30st – September 3rd
S.Gautsch, T. Akiyama
10 Persons max., min.3
This course will cover an introduction into the required microfabrication steps and the basic consideration for the design of such a device. Each participant will fabricate his/hers own wafer with AFM chips in the clean-room. A few chips will then be used for performing plain AFM measurements and characterized by measuring the resonance frequency of the cantilever. The tip quality will be assessed by reverse-AFM imaging as well as by SEM observation.
Goal: Each participant knows how to work in a clean-room environment
Each participant has fabricated his own wafer with AFM-chips.
Each participant can characterize an AFM-chip

### Zusatzinformation zu Nanotechnologie Praktikum nach SS 2010 an der EPFL Neuchâtel

**Dauer**: 1 Woche ganztägiger (09:00 - 18:00) Laborteil in Neuchâtel (Nanolithographie dieses Jahr ausnahmsweise über 4 Tage)
1 Woche für das Verfassen des Berichts.
Abgabe des Berichts spätestens 6 Wochen später

**Organisation**: Die Teilnehmenden können entweder in Neuchâtel im Studentenheim logieren (120 Fr für 4 Übernachtungen mit Frühstück), oder mit dem Zug pendeln. Die Zimmer im Studentenheim müssen verbindlich reserviert werden.

| | | |
|---|---|---|
| *Zugfahrplan:* | BS ab: 7:05 | NE an: 8:32 |
| | NE ab: 18:24 | BS an: 19:53 |

Kurssprache ist Englisch.

**Entschädigung**: Die Reise- und Unterkunftsspesen werden den Teilnehmenden gegen Vorlage der entsprechenden Belege bis zum Gegenwert von maximal 200.00 SFr zurück erstattet.

## Paul Scherrer Institut

### 22.Micro- and nanofabrication of surface topographies
Name Kursverantwortlicher: M. Bednarzik, H. Schift, J. Gobrecht
Ort: Paul Scherrer Institut, 5232 Villigen PSI
Dauer und Art des Kurses: 1 week intensive laboratory course
Maximale Teilnehmerzahl: 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 nano-devices, -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 clean room design and operation, laboratory safety and emergency instructions;
- Thin film technologies: metal evaporation with e-gun evaporator, deposition of silicon-nitride by plasma-enhanced chemical vapour deposition;
- Pattern definition by photolithography, electron beam lithography: resist spin-coat, pre-bake, exposure, development, hardbake.
- Pattern transfer: wet etching, dry etching processes, resist stripping, lift-off;
- Replication patterning techniques of topological and chemical structures: fabrication of stamps, polymer molding by nanoimprint lithography, residual layer etching, pattern transfer, surface modification;
- Quality control and characterization: optical microscopy, interferometric film thickness determination, surface profiling, scanning electron microscopy.

**In this course** the students will get aquainted with 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 characterisation.
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:
http://LMN.web.psi.ch
Prof. J. Gobrecht,Paul Scherrer Institut, Tel.: 056 310 2529
Jens.gobrecht@psi.ch

**24. Determination of the chemical and the magnetic structure of novel materials**
V. Pomjakushin, L. Keller, J. Schefer
Prerequisite: Solid State Physics
Location: Paul Scherrer Institute, Villigen PSI, http://lns.web.psi.ch
Minimum: 2 maximum: 5

Learning the basic principles of neutron diffraction techniques in order to determine the chemical and magnetic structure for polycrystalline and single crystalline materials (for reference, see textbook of G.L. Squires [1]).

Magnetism is all-around in condensed matter physics [2]. This practical course allows learning how to perform a neutron powder diffraction experiment, apply all the necessary corrections and as well as to analyze the data in order to determine the chemical and the magnetic structure of novel materials. We will perform a data collection below and above the magnetic ordering temperature.For this purpose we will use a helium flow cryostat and and/or a closed cycle refrigerator installed on one of our diffraction instruments HRPT (short wavelength) or DMC (long wave length) respectively and the single crystal diffractometer TriCS, all located at the Swiss Neutron Spallation Source SINQ in Villigen PSI, Switzerland. (http://sinq.web.psi.ch/sinq/instruments.html)

We will investigate for example the multiferroic material $NdFe_3(^{11}BO_3)_4$ [3] or a similar system depending on the present demand in ongoing research.

Optional Introduction Course on Methods in Materials Sciences:
Optionally, we can offer to participants only to be guests in part of a preparation school on materials science to be held in Rennes/Frances within the framework of Erasmus Mundus (http://etudes.univ-rennes1.fr/mamaself, September 2009).

[1] G.L. Squires, Introduction to the theory of thermal neutron scattering, Dover Publications (1978)
[2] St. Blundell, Magnetism in Condensed Matter, Oxford University Press
[3] P. Fischer et al., J. Phys.: Condens. Matter **18** (2006) 7975–7989

**25. μSR spectroscopy (Muon Spin Rotation/Relaxation) of magnetic and superconducting materials.**
E. Morenzoni, A. Amato, R. Khasanov, T. Prokscha
Prerequisite: Solid State Physics
Location: Paul Scherrer Institut, Villigen PSI, http://lmu.web.psi.ch/
Minimum 2, Maximum 5

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

This practical course allows learning how a μSR experiment is performed and analysed. It gives detailed insight into a modern local probe technique of condensed matter research making use of 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 μSR beam line (GPS, http://lmu.web.psi.ch/facilities/gps/gps.html) and at the Low Energy Muon beam line (LEM, http://lmu.web.psi.ch/lem/index.html) at PSI.

Actual problems of condensed matter physics are chosen:

- Microscopic investigations of the phase diagram, magnetic and superconducting properties of the recently discovered iron based superconductors (H. Luetkens et al, *Nature Mater.* **8,** 305 (2009).
- Symmetry and length scales in the vortex state of a type-II superconductor.
- Measurement of the magnetic field profile on nm scale and direct determination of the magnetic penetration depth in a thin film of a high $T_c$ superconductor (T.J. Jackson, Phys. Rev. Lett. **84**, 4958 (2000)).

The first day a general introduction about the μSR technique (including instrument and beam line) and its use to investigate local magnetic and superconducting properties is given.