I. Instructions for subscription to the practical courses

Students must subscribe to HISQIS and additionally select a particular course in Doodle.


The titles of the practical courses are enumerated with letters (A, B, C …) and numbers (1, 2, 3 …). The practical courses are for three study programmes, listed in the descending degree of priority:


- middle priority: **WKMBP** (weiche kondensierte Materie und biologische Physik), no corresponding lecture, courses enumerated with numbers (1, 2, 3, …)

- lowest priority: **Master Chemie MRC-04**, lecture “Modern Topics in Physical Chemistry of Polymeric Materials”, courses enumerated with numbers (1, 2, 3, …)

**OME students** subscribe first to the topics enumerated by letters (A., B., C., ...) and after these courses are full, they start to subscribe to courses enumerated by numbers (1., 2., 3.). It is not necessary to start with letter A. Students can select free course (A, B, C, ...) that they find most interesting.

**WKMBP and Master Chemie MRC-04 students** subscribe to the topics enumerated by numbers (1., 2., 3.). It is not necessary to start with number 1. Students can select free course (1, 2, 3, ...) that they find most interesting. If some courses enumerated by letters (A, C, B) are still free, they can subscribe to these courses.

When subscribing to Doodle, add Mr. or Ms. to your name (so that we can address you properly) and add your study programme, e.g. “Mr. Neumann, Dominique (OME)”
II. Information to the course

The practical course takes 1 week. One or two students accompany one supervisor for a week and make experiments and data evaluation with the supervisor according to his/her instructions.

Some supervisors can speak only German, some can speak only English, some can speak both. The language of the course is indicated behind the title (DE ... only German, EN ... only English, DE/EN ... German or English, DE+EN ... German and English (course has 2 supervisors, one can speak only German, one can speak only English))

The list of topics for practical courses are is published on Webpage of Prof. Fery by 15.12.2018:


Students have to register for the practical course in HiSQIS and additionally select a particular course in Doodle between 21.12.2018 and 31.01.2019. The link to the Doodle will be published under the link above.

The regular time for the course is 04.03.2019 to 08.03.2019.

To be allowed to do the practical course, every student has to hear occupational safety instructions. These will be given on 31.01.2019 14:50 – 16:20 in IPF, Hohe Str. 6, 01069 Dresden in the conference room.

Contact your supervisor until 16.02.2019 to arrange the details of the course, e.g. instructions to experiments, meeting point.

Every student has to write his/her own protocol, even if 2 students work in one course. The protocols will be graded. The protocol should be max. 5 pages long. There should be 1 or 2 pages of short introduction and 3 to 4 pages of report about what was done during the course. You have to submit it to your supervisor until three weeks after the experimental week (regular date 31.03.2019).

The supervisor has two weeks to correct and grade the protocol (regular date 14.04.2019).

You can write your feedback to the organization and content of the practical course here
https://docs.google.com/document/d/1MB_3hLP4yEW8kt5WTiQCln9oAcZxrhVClYe0qQPh8o/edit?usp=sharing

Do not share the google-docs links with anyone who is not involved in the practical course.
III. Abstracts of the practical courses
A. Determination of small-scale elastic and plastic material properties of polymers using nanoindentation (DE/EN)

Dr. André Clausner (Mr.)
Nanomechanics and reliability for microelectronics, FH IKTS Dresden/Klotzsche
E-Mail: andre.clausner@ikts.fraunhofer.de
1-3 students

Abstract:

Since the last 20 to 30 years the determination of mechanical properties in small scales became increasingly important. Through the years the main technique to measure such properties was and still is nanoindentation which developed to a mature and well understood technique these days. Nevertheless different tasks and materials lead always to new challenges if their mechanical properties have to be measured accurately in small dimensions. And besides mastering the measuring technique also the specimens themselves are often challenging as materials tend to behave differently in microscopic than in macroscopic scales.

Consequently, the aim of this course is to get an introduction to the nanoindentation technique and its variants. This includes e.g. an introduction to the devices, to the theory behind the data analysis, the necessary calibration procedures, and the measurements itself. The studied samples will be bulk polystyrene and PDE specimens. Due to the time-dependent elastic and plastic behavior of polymers also the study of the influence of different loading speeds on the resulting material parameters is a part of the course. In-situ nano-mechanical testing in different microscopes will be briefly shown and discussed. In the end the participants need to write a scientific protocol which contains all the workflow and analyzed data acquired during the course.
B. Mechanical characterization of materials on nanoscale with help of atomic force acoustic microscopy – special application 50 nm thin films (DE/EN)

Dr. Malgorzata Kopycinska-Müller (Ms.)
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01109 Dresden
1-2 students

Atomic force acoustic microscopy is a method based on atomic force microscopy and basic knowledge in using the AFM in contact mode is of advantage during this practical course. This films are essential and critical components of all electronic devices (among others). Very often, due to their nano-dimensions the mechanical properties of a thin film differ from that of bulk equivalent. As the film thickness decreases, it becomes more difficult to determine their mechanical properties with help of macroscopic method and one must restore to AFM based methods as they offer supreme lateral and depth resolution.

The activities planned for this practical course include:
1. Learning the basics of AFM operating in contact mode
2. Principle of atomic force acoustic microscopy
3. Acquisition of contact resonance spectra on reference materials and thin film samples
4. Data evaluation

The report should include a short description of the principle of the atomic force acoustic method, graphic presentation of the experimental results and summary of the data analysis. The duration time is planned for about four to five days, depending on the previous AFM experience of the student.

The practicum will take place within times specified for the whole course.
C. The full-field X-ray microscopy study of the composite materials at the nano-XCT (EN)

The systematic development of new advanced materials with complex structures demands to invent a new or to improve existing techniques for materials characterization. High resolution X-ray microscopy and X-ray computed tomography are suitable techniques for two and three dimensional investigation of structural materials, like composites. The technique allows to analyze the internal structure in sub-100 nm scale, without cutting or sectioning of the region of interest, hence it provides non-destructively 3D image data. The 3D volumetric data allows to extract the key morphological and structural parameters of the material such as density variations (fiber, matrix), porous, inclusions at the micro and nanoscale.

This practical course will provide the work at the X-ray microscope to perform tomography data as well as data reconstruction and analysis. The student will learn how to operate with samples for the nano-XCT tool and realize tomography; how to reconstruct and analyze data set; the microstructural characterization of the composite materials.

In this practical course we will include the following activities:
1. Manipulation of the samples and insert them into the microscope
2. Nano-XCT experiment
3. Data analysis.

Students will learn
1. How to use the nano-XCT tool and how to extract 3D tomography data
2. How to reconstruct and analyze the data
3. How to perform a nondestructive nano-scale characterization of composite materials.

Contact person: Kristina Kutukova (Ms.)
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D. Preparation and Inspection of solder balls in a microelectronic package (DE/EN)

The inspection of solder joints in microelectronic is necessary for each new technology in order to estimate the reliability risks of the later products. During soldering intermetallic compounds are formed. They show different mechanical properties and the interfaces between them are prone to cracking during thermal and mechanical stress.

In this practical course we will perform the following experiments

1) cross section preparation of a microelectronic package by embedding, grinding and polishing
2) metal sputtering with a sputter coater
3) imaging surface and cross section with the SEM
4) Acquisition of EDX spectra and EDX mapping
5) studying of the influence of different imaging parameters on the image quality
6) cross section preparation of a selected area with the Focused Ion Beam
7) imaging of the FIB cross section and geometrical measurements

Students will learn

⇒ how to use the preparation equipment by hands-on learning
⇒ get to know the principles of Scanning Electron Microscopy
⇒ get to know the principles of Focused Ion Beam Technique

Contact person:
Dr. Rüdiger Rosenkranz (Mr.), e-mail: ruediger.rosenkranz@ikts.fraunhofer.de Tel. +49 351 88815 529
1. Fundamentals of ellipsometry (EN)

Ellipsometry is a versatile non-destructive and non-contact optical technique for thin film characterization. It implies measuring the change in polarization of the light reflected from the sample. The experimental results are interpreted through the intensity ratio of the S and P polarization components, which provides an access to the material properties. This method enables precise characterization of several parameters including layer composition and thickness, optical constants, crystallinity, anisotropy, uniformity and surface roughness. In general, ellipsometry is a technique that is used on a daily basis in basic research in physical sciences, semiconductors, flat displays, energy storage devices, biosensors and optical coating industrial applications.

This practical course includes the following experiments:
1) Sample preparation by the spin-coating technique.
2) Sample characterization by the spectral ellipsometry.

What one can learn during this course:
1) How to use the spin coating method for the preparation of thin films? What parameters affect the quality of the sample?
2) How to perform ellipsometry?
3) How to build a model of the studied sample and fit experimental results?
4) How to evaluate the results and extract meaningful parameters, such as optical constants, thickness an roughness of the surface?

Literature:
3) https://www.jawoollam.com/resources/ellipsometry-tutorial/what-is-ellipsometry

Contact person: Olha Aftenieva (Ms.)
aftenieva@ipfdd.de
+4915257443259
2. Oberflächenfunktionalisierung mittels AD-Plasma zur besseren Klebbarkeit von Kunststoffen (DE)


In diesen Kurs werden folgende Experimente und Untersuchen durchführen:

1) Oberflächenfunktionalisierung von Kunststoffen mittels einer Atmosphärenplasmaanlage
2) Benetzungsmessung der behandelten Oberflächen
3) Herstellen und Prüfen von Klebeverbindungen

Lernziel:

- Aufbau und Funktionsweise einer Atmosphärenplasmaanlage
- Oberflächenfunktionalisierung von Kunststoffen mittels Plasmabehandlung
- Kennenlernen der BenetzungsMESSung zu Bewertung der Oberflächenfunktionalisierung
- Bestimmung mechanischer Kennwerte an Klebeverbindungen

Kontaktperson: Andre Knapp (Mr.)
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3. Encapsulation of nanoparticles in block copolymer micelles (EN)

Core/shell nanoparticle (NP) architectures, in which a layer of organic material surrounds an inorganic nanoparticle core, can be used both as a means to improve the stability and surface chemistry of the core nanoparticle and as a way of accessing unique physical properties that are not possible from one nanomaterial alone. Such nanoparticle encapsulated structures are very interesting objects for investigation from application point of view (catalysis, plasmonics, optical waveguides, sensors etc.), as well as for fundamental understanding of encapsulation process. Nanoparticles (NP) can be encapsulated inside preformed di-block copolymer (BCP) micelles by using suitable solvent conditions for BCP and NP both. Surface modification of as synthesized NP with an appropriate ligand e.g. coated with polymer shell, is required prior to the encapsulation. Control over nanoparticles distribution in BCP micelles can be achieved by adjusting various parameters, such as BCP morphology, solvent selectivity, solvent ratios, dosing conditions etc.

In this practical course we will perform following experiments:
1) Synthesis & modification of nanoparticles with target size and narrow size distribution (Au or Ag);
2) Encapsulation of modified NPs in BCP micelles with varying NP/BCP mixing conditions (e.g. solvent ratio, solvent nature, dosing rate etc.)
3) Characterization of encapsulated micelles using scanning electron microscopy (SEM), transmission electron microscopy (TEM), dynamic light scattering (DLS), and spectroscopic methods.

Student will learn
- How to synthesize & characterize NP, modify their surface and purify NPs;
- How NP/BCP micelles are prepared and which parameters are important.
- How the particles are getting inside the micelles

Contact Person: Labeesh Kumar (Mr.)
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Polymer brushes are densely packed assemblies of polymer chains that are end-attached to a surface or interface. They can be used to control the surface properties in order to design smart surfaces exhibiting responsive adsorption, specific adhesion, or switchable wettability. Weak polyelectrolyte brushes, also called annealed brushes, are appealing systems due to the degree of dissociation of the chains, which can be varied by changing the pH or ionic strength, resulting in stimuli parameters for reversibly tuning the polymer conformation or its interaction ability. PAA brushes are interesting weak polyelectrolyte brushes since the structure of PAA is well defined and enables the investigation of the dissociation effect of charges on the behavior of surface-attached chains. Understanding of such model polyelectrolyte brushes can be helpful to comprehensively predict the properties of more complex charged macromolecular assemblies such as biopolymers.\(^1\)

In the practical course, swelling measurements and protein adsorption on polyacrylic acid (PAA) brushes are performed by means of in-situ VIS ellipsometry. The degree of swelling (swelled / dry), the percentage of buffer and the amount of adsorbed protein from the ellipsometry data will be evaluated. The significant steps in the measurement process should also be documented. PAA brushes on the SiO\(_2\) wafer will be prepared. After dry ellipsometric characterization, in situ ellipsometry will be done in two distinct experiments in order to investigate the swelling process and protein adsorption in PAA brushes.

Ms. Saghar Nazari, nazari@ipfdd.de Phone. +49 351 4658 632

5. UV-Vis-NIR Absorption and Scattering Spectroscopy of Plasmonic Nanoparticles (DE/EN)

Aim of this practical course is to get insight into the synthesis of bimetallic plasmonic nanoparticles and their optical characterization methods. Utilizing a syringe pump, single crystalline gold nanospheres will be overgrown with silver to form a cubic shell around the gold spheres. During the overgrowth process plasmonic behavior, especially absorption and scattering, changes drastically. This will be observed utilizing a state of the art integrating sphere setup in an UV-vis-NIR spectrometer. Experimental observations can be backed with FDTD calculations.

In this practical course we will perform the following experiments:
   1) Synthesis of bimetallic nanoparticles, consisting of a gold nanosphere core and a silver cubic shell.
   2) State of the art absorption and scattering UV-Vis-NIR spectroscopy utilizing an integrating sphere setup.
   3) Backing of experimental data with finite-difference-time-domain (FDTD) simulations.

Student will learn
   ⇒  How to synthesize bimetallic nanoparticles, utilizing a syringe pump.
   ⇒  UV-Vis-NIR spectroscopy with an integrating sphere setup.
   ⇒  First glimpse into FDTD simulations

Contact person: Daniel Schletz (Mr.)
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Tel.
6. Synthesis of Porous Particles for Water Treatment (DE/EN)

Micro- and mesoporous organic polymers have attracted great attention during the past decade. These types of polymers benefit from their very high surface area due to pore sizes below 2 or 50 nm in diameter, respectively. This porosity can be achieved by different methods. We will mainly focus on the templating approach. Another task will be the formation of monodispersed particles. The particles will be characterized by a variety of methods such as SEM, dynamic light scattering, gas sorption experiments, IR, XRD and elemental analysis. The obtained particles will be investigated for their potential application as adsorber for heavy metal ions.

In the practical course we will perform the following experiments:
1. Synthesis of monodisperse particles with targeted particle size and porosity
2. Characterization of the particles (porosity and zeta potential measurements)
3. Adsorption investigations (as batch experiments)

Students will learn:
- How to synthesize and purify porous resin particles
- How to characterize porous particles in terms of functional groups and porosity
- How to perform sorption experiments

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7. Smart bio-inspired polymeric surfaces with tunable underwater adhesion properties (EN)

During the last decades, a number of new adhesives have been developed for applications on dry surfaces. Nonetheless, most of synthetic well-known and widely used adhesive systems suffer from lack or complete failure of their properties when they are brought to a moist environment. Therefore, nowadays one of the formidable challenges in material science is engineering of durable adhesive bonds to wet surfaces. On the other hand, several natural organisms are known to provide strong controllable underwater adhesion, for instance marine animals like mussels and limpets. Thus, it is essential to derive inspiration and knowledge from these biological systems, and using this knowledge to develop performing synthetic materials. However, design of polymeric-based systems, which can be utilized as smart glue under water, is still highly challenging.

We are using polymer brushes to obtain responsive surfaces able to provide strong and tunable underwater adhesion. Polymer brushes are polymer chains tethered to one end to a solid substrate, providing more thermal and mechanical stability compared to adsorbed monolayers. A number of chemical functionalities can be placed along the polymer chain in order to obtain responsive polymers, able to change their properties according to external stimuli such as temperature, pH, ionic strength, light or magnetic fields.

In this training course, we will perform the following experiments:

1. Modification of solid substrates for surface-initiated polymerization
2. Synthesis of responsive polymer brushes
3. Characterization of the final layer using ellipsometry and NMR

The student will learn:

- How to design and synthetize responsive polymer layers
- How to confirm the success of the synthesis by several techniques
- How to investigate the responsive behavior of the final layer

This knowledge and know-how will be useful for the student’s future career, both in academic or industrial environment. You are welcome to join our group and to learn with us!

Contact: Ugo Sidoli (Mr.) Dr. Alla Synytska (Ms.)
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8. Oberflächenstrukturierung durch Faltenbildungsprozesse mittels Atmosphärenplasma (DE/EN)

Oberflächenstrukturierungen sind in vielen technischen Anwendungsbereichen von hoher Bedeutung, sei es um optische, tribologische oder haptische Eigenschaften zu beeinflussen. Faltenbildungsprozesse bieten eine Möglichkeit isotrope Oberflächenstrukturierungen mit hoher Periodizität schnell und einfach herzustellen. Die Wellenlängen der Faltenstrukturen können je nach Herstellungsbedingung (z.B. Schichtstärke oder mechanische Eigenschaften der Schicht bzw. der verwendeten Substrate) im Bereich weniger 100nm bis mehrere µm reichen. Über die Prozessparameter können die gewünschten Strukturen gezielt erzeugt werden.

In diesen Kurs werden folgende Experimente und Untersuchen durchführen:
1) Oberflächenstrukturierung mittels einer Atmosphärenplasmaanlage
2) Topografieuntersuchung mittels AFM und Konfokalmikroskopie

Lernziel:
- Aufbau und Funktionsweise einer Atmosphärenplasmaanlage
- Erzeugung einer Oberflächenstrukturierung mittels Faltenbildungsprozessen
- Kennenlernen von Messverfahren zur Topografiebestimmung

Kontaktperson: Sebastian Stelzner (Mr.)
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Fabrication of thermoresponsive microgels by droplet-microfluidics.

An important task that can be performed in microfluidic flow cells is the formation of microdroplets, or the generation of segmented flow in general - as independent reaction vessels and templates in self-assembly processes. On this account, droplet-based microfluidics has emerged as a powerful tool in chemical and biological research as it provides new opportunities for the miniaturization of chemical and biochemical reactions. Libraries of microdroplets are applicable as platforms for high-throughput screening of aptamers and enzymes in drug discovery and protein crystallization studies, for instance, overcoming the limitations of conventional screening techniques in combinatorial chemistry and biotechnology, which usually require large of amounts of consumable materials for performing the same tasks.

In materials science, droplet-based microfluidics is particularly useful for preparing uniform, monodisperse polymer particles with precise control over their size, composition and morphology, e.g. for mimicking the natural environment of cells in 2D and 3D or performing biological functions in vitro. Heat, redox reactions and light are most commonly used to initiate polymerization reactions in droplets. A UV-initiated polymerization reaction is generally preferred due to the rapid kinetics that preserves the internal microstructures and the precise spatial and temporal control over the reaction. Various reports have shown UV-initiated polymerization in combination with droplet microfluidics for the fabrication of microsheres and microcapsules.

As part of this lab course, polymer particles based on PNIPAM [poly(N-isopropylacrylamide)], approx. 15 to 20 μm in diameter, will be fabricated. NIPAM, a stimuli-responsive polymer with a lower critical solution temperature of 32°C, is widely applied as synthetic monomer e.g. for preparing thermoresponsive valves and switches. The experimental setup requires two high-precision syringe pumps, a microfluidic flow cell with flow-focusing geometry (10 to 15 μm at the droplet-forming nozzle), a simple light microscope and a high-speed camera for single-droplet observations.

In this practical course we will perform following experiments:

1) Design and fabrication of microfluidic flow cells by soft lithography and additive manufacturing;
2) Preparation of water-in-oil microemulsions as templates for hydrogel particles;
3) Microgel particle fabrication by UV-polymerization, and their characterization (size, thermo-sensitivity).

Student will learn:

- How to control and manipulate fluid flows in the picoliter range in microfluidic flow cells;
- How to form defined microemulsions as templates for hydrogel particle fabrication;
- How to characterize thermoresponsive microgels employing light and fluorescence microscopy.

Contact person: Thomas Heida, Nicolas Hauck

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10. Biopolymers as Adsorber and Flocculant agents for Water Treatment (DE/EN)

Polymers are widely used as flocculants and adsorbents for suspensions in many industrial applications (e.g., papermaking, water treatment, or food processing). In the last years, the demand for biopolymers has increased due to their unique properties such as biocompatibility, biodegradability, and sustainability.

In surface waters, turbidity as colloidal solid particles is virtually always contained. Turbidity as well as dissolved ions or molecules can be removed from water by flocculation. Flocculants can be organic polymers, inorganic salts or a combination of both. Efficient flocculation with flake separation is the requirement for minimizing the turbidity and particle content of a water. The adsorption and flocculation process is very complex due to an interplay between molecular weight, solvent quality, interaction energy between the monomers and surface, the polyelectrolyte charge, the surface charge and the ionic strength. Therefore, all these parameters need to be investigated to obtain a full understanding of the mechanism.

In the practical course we will perform the following experiments:
1) Characterization methods for adsorber materials and flocculants (particle size distribution measurements, zeta potential, rheology, turbidity measurements etc.)
2) Flocculation investigations
3) Sorption experiments (batch and/or column)

Students will learn:
- Modify and purify the adsorber/flocculant agents
- How to characterize adsorber/flocculant agents
- How to perform sorption or flocculation experiments
- How to work with ICP-OES

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