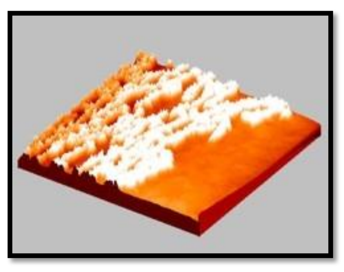
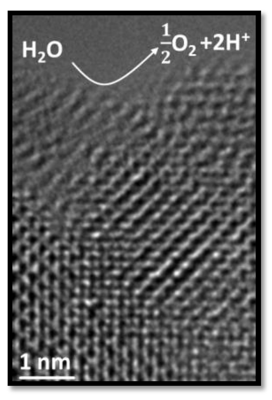
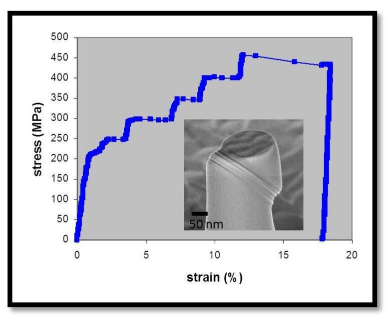
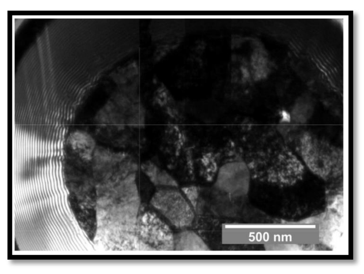
Bachelorarbeiten am Institut für Materialphysik

What do we study?









- What happens when you put hydrogen in a metal?
- What happens when you charge a battery?
- What happens during an electrocatalytic reaction?
- Can we study the effect of catalysts on the water splitting reaction directly under an electron microscope?
- How do material properties change upon miniaturization toward nanometer length scales?
- Can we fabricate high-quality X-ray optics by pulsed laser deposition?
- What do energy conversion processes look like at the atomic scale?

At the IMP we want to understand how **material properties** emerge from the interactions of single atoms and to apply this understanding to develop new and better materials for applications such as **renewable energy** and **information technologies**.

Do you also find these questions interesting? Do you enjoy our introductory lecture **"Einführung Materialphysik"** and want to learn more?

Then do your Bachelorarbeit with us!

IMP research groups

Nano-Mechanics (Prof. Cynthia Volkert): Mechanical stress can impose huge free energy changes in materials, thereby altering both the equilibrium and the dynamic behavior, particularly in nanoscale materials. We investigate a variety of different nanoscale model systems using in-situ electron microscopy and micromechanical testing, with the goal of revealing the underlying principles controlling material stability, defect dynamics, and energy dissipation.

Nanoskalige multifunktionale Oxide (Prof. Christian Jooß): Komplexe Übergangsmetall-Oxide bzw. Chalogenide zeigen durch das subtile Wechselspiel zwischen elektronischen, Spin- und Gitterfreiheitsgraden sowie den Defektstrukturen eine große Vielfalt von faszinierenden Eigenschaften, die neue Mechanismen der Energiewandlung in thermoelektrischen, photovoltaischen bzw. elektrochemischen Prozessen ermöglichen. Nanostrukturen und Grenzflächen in diesen Materialien ermöglichen dabei die Herausbildung neuartiger und steuerbarer Materialeigenschaften, die für die Energiewandlung von großem Interesse sind.

Komplexe dünne Schichten / Laserdeposition (Dr. Sarah Hoffmann-Urlaub): Complex thin films and multilayers consisting of different materials are of high interest for applications. For their preparation we use the versatile pulsed laser deposition (PLD) technique allowing us to deposit almost any kind of material.

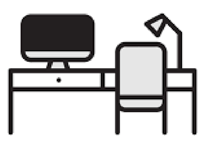
Atomic Scale Modeling (Dr. Richard Vink): Computer simulations can provide quick insights into material behavior at the fraction of the cost of a real experiment. We are currently modeling AFM friction experiments using molecular dynamics to see how the underlying material structure affects friction. Our simulations run on high-end computer hardware which we also make available to Bachelor students who choose to write their thesis in this field.

What do we offer our Bachelor students?

As IMP Bachelor student you become **integrated into our research groups**. In addition to your direct supervisor, we offer you a proper on-boarding where you get to know the whole institute, and we make sure you are updated on our safety regulations.

Being integrated into a research group gives you access to our **staff topical meetings**. Here you can actively participate by presenting your results, posing questions you might have, thereby directly benefiting from the wealth of knowledge of our experts.

Extend your horizon: Visit our (almost) **weekly Thursday seminar** to learn about new topics at the forefront of research in Materials Science. Includes free coffee and cookies!



We offer **basic working space** to all our Bachelor students. Feel free to visit room **D.03.133** to check it out!

Bachelorarbeit: Typischer Ablauf

Nov – Ende WS	Bachelorbörse / Beratungsgespräche & Kennenlernen Betreuer vor Ort am Institut
Jan - Apr	**Spezialisierungspraktikum (6C)** Vorbereitungsphase am Institut (4 Wochen, Schriftlicher Bericht, ~10S, Benotet, s. B.Phy.407)
Sommer	**Bachelorarbeit (12C)** Durchführen Experiment o. Simulation, Schreiben Arbeit (14 Wochen insgesamt, davon 10 Wochen Messzeit, 4 Wochen Schreiben, ~ 40S, Benotet)

Abgabe Prüfungsamt: Aug/Sep

Falls erwünscht: Abschlussmodul (4C)
Sie können sich mit diesem Modul für den Bereich **Materialphysik** zertifizieren lassen (Vortrag & mdl. Prüfung + Vorleistungen, s. **B.Phy.1412**)

Aktuelle Bachelorarbeiten

Effect of the structure on the onset of plasticity in metallic glasses ***(Volkert)***

Computer simulations of adsorbate vibrational relaxation on structured substrates ***(Vink)***

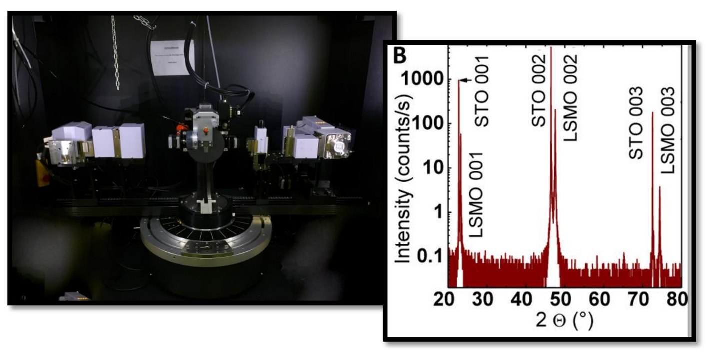
Atomistic Simulations of Elastic and Plastic Deformations in Gold Nanowires ***(Volkert)***

Preparation and Analysis of Insulating Layers for the 3ω-Method ***(Jooß)***

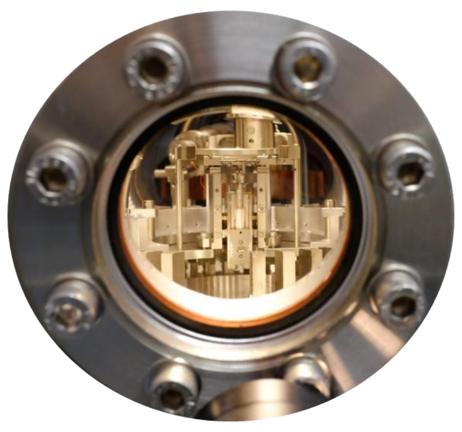
Untersuchung der Sauerstoffentwicklungs-reaktion an einem LiMn2O4-Katalysator in Lithiumhydroxid ***(Risch)***

Investigation of grain size in ball-milled and heat-treated nano-crystalline Fe in dependence of C content ***(Borchers)***

IMP: Some of our equipment & research methods



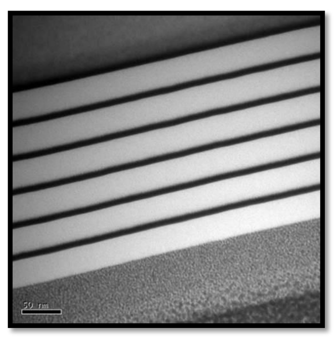
XRD apparatus with example measurement of an LSMO sample.



UHV-Tunnelmicroscope (Omicron, Micro).

Elektrochemische Methoden: Wir benutzen elektrochemische Methoden, um den katalytischen Mechanismus von Elektro-katalysatoren zu bestimmen sowie zur Materialsynthese.

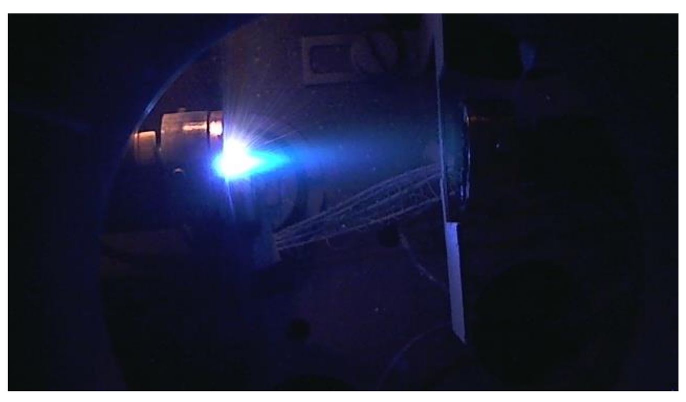
Das Bild zeigt Studierende beim Aufnehmen einer Strom-Spannungskennlinien, die auch in anderen Bereichen der Physik weit verbreitet sind. Die so gewonnenen Einsichten sind wichtig, um die Mechanismen der **Energiespeicherung und -wandlung** zu verstehen.



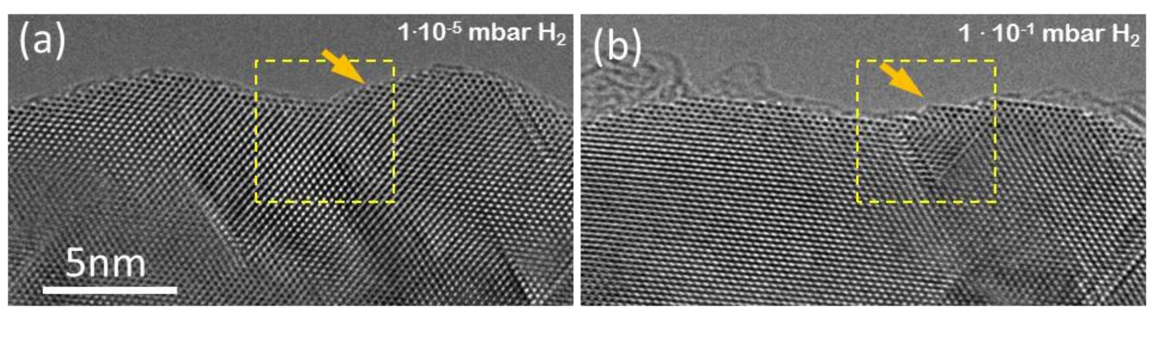
Thin Film Deposition: To understand how material properties depend on crystallographic structure, we need **high-quality samples** with very precise predefined structures. We are experts on creating such samples using a number of different vapor deposition methods. The picture shows a metal/polymer multilayer material prepared by us.

Atomic Scale Modeling: We routinely use computer simulations to complement experiments. Simulations provide detailed information, such as particle positions as a function of time, and help to understand phenomena occurring in real materials. The picture shows a molecular dynamics setup to study **nano-scale friction**.

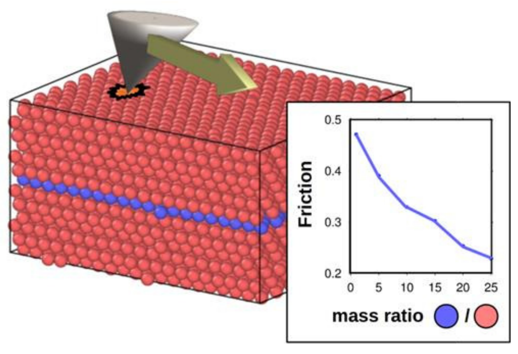
Titan 80-300 environmental atomic-resolution scanning / transmission electron microscope.

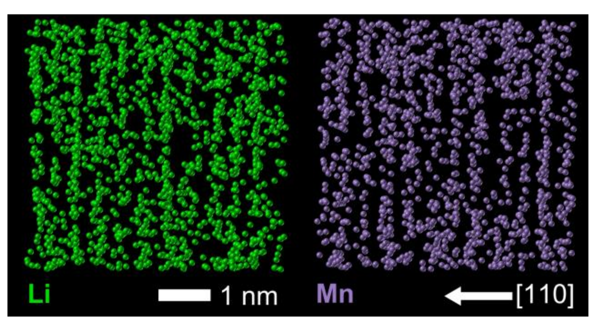


Plasma plume during the laser based deposition of tungsten.



In-Situ Electron Microscopy: We are able, using environmental TEM, to observe real-time structural changes in a material at near atomic resolution under the interaction of that material with a gas. These experiments can be used to probe material behavior under conditions which are similar to **real operation conditions**. The picture shows how Pd changes in the presence of hydrogen.





Atom Probe Tomography: With this method we can reconstruct the position of (nearly) single atoms in a material. As shown in the picture, we use this to probe the structure of $LiMn_2O_4$, a widespread **battery material**.

Bachelorarbeiten am Institut für Materialphysik

Projekte / Themenbereiche 2019 / 2020

- If you are interested in our offered projects or want to know more, please talk to us directly at the poster, or contact the responsible supervisor as listed in the project description.
- This poster is also available for download at our institute website, under Section **Lehre**.

Pulsed Laser Deposition

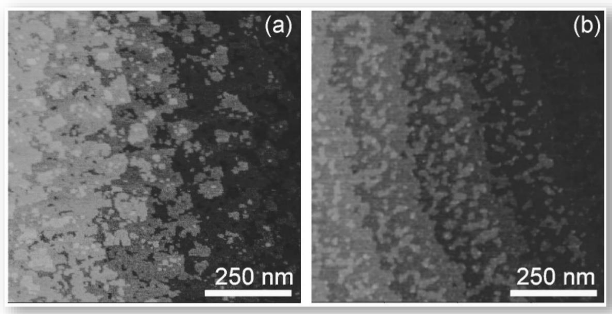
Mit Hilfe der Pulsed Laser Deposition (PLD) stellen wir dünne Schichten im Bereich weniger Nanometer bis hin zu Mikrometern mit hoher Qualität her. Hierbei können wir durch die Wahl der Prozessparameter die Struktur der Schichtsysteme gezielt beeinflussen. Zu unseren wichtigsten Analyse Methoden gehören unter anderem REM, XRD, XRR, AFM, TEM und Profilometrie.

Bachelor Projekte:

1. Ziel dieser Arbeit ist es, die **LabView** basierte Software zur **Steuerung** eines **Excimer-Lasers** zu optimieren und einen Code-Baustein zur An-steuerung eines **Ab-schwächermoduls** zu erstellen.

Abschwächermodul von Coherent

2. Ziel dieser Arbeit ist es, herauszufinden, welchen Unterschied eine **intervallartige Deposition** (Burst Modus) im Vergleich zur standardmäßigen gepulsten hat. Hier sind die Anzahl der Pulse vor der Relaxationszeit und die Repetitionsrate entscheidende Prozessgrößen. Es wird erwartet, dass die Schichten kleinere Körner aufweisen, ein vorwiegend **zweidimensionales Wachs-tumsverhalten** zeigen und daher verspannt sind.



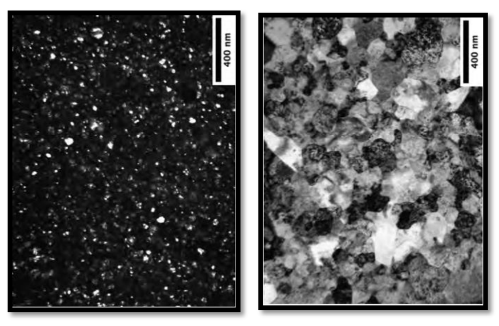
AFM Aufnahmen von $SrTiO_3$ Schichten hergestellt im a) Standard- und b) Burst-Modus
doi: 10.1063/1.123235

Kontakt: Dr. Sarah Hoffmann-Urlaub, shoffmann@ump.gwdg.de, D02.120, 39-29642

Defactants

Im Vordergrund stehen **Arbeiten** auf folgenden Gebieten:

- Thermodynamik von Legierungen, metastabilen Legierungen, Keimbildung und Wachstum.
- Wasserstoff in Metallen.
- Segregation von gelösten Atomen und Diffusion in inneren Grenzflächen.
- Segregation von gelösten Atomen an Gitterbaufehlern.
- Neue nanostrukturierte Materialien durch Defactants.



TEM Bilder: links: Fe-B-Legierung, rechts: Fe-O-Legierung. Jeweils nach 100 h Kugelmahlen & 1 h Wärmebehandlung bei 600 °C.

Kontakt: Dr. Christine Borchers, chris@ump.gwdg.de, C.03.104, 39-25584

Nanomechanics

Growing Ice in an Electron Microscope

The goal of this project is to optimize the conditions for growing thin and smooth layers of water ice on cooled surfaces inside the vacuum chamber of a dual electron/ion beam microscope. Conformal 10 to 100 nm thick ice layers are needed for two projects: ice lithography – a new idea to avoid redeposition during patterning in the focused ion beam microscope – and to prepare samples for studies of the ice/solid interface with Atom Probe Tomography. The project will involve varying the temperature and voltage of the substrate on which the water vapor is deposited to see under which conditions a smooth, dendrite free, amorphous ice film can be grown.

Work Plan:
The first two steps will be to learn to use the water vapor injection system in the new focused ion beam microscope and the cryogenic cooling stage. The stage allows set temperatures down to 90 K to be reached and the electrical potential to be set. Ice films will be grown on the cooled, electrified substrate and their morphology, microstructure, and thickness investigated with scanning electron beam imaging and focused ion beam fabricated cross-sections. Once high quality ice films have been achieved of the desired smoothness and thickness, ion beam lithography tests will be performed to see how effective the ice film is in removing redeposited material on heating up to room temperature.

Experimental Methods:
A new Focused Ion Beam Microscope will be installed at the Institute of Materials Physics which allows water vapor to be locally introduced into the vacuum chamber. The following methods will be learned and used independently by the student: vacuum technology, cryogenic technology, scanning electron microscopy (SEM), focused ion beam (FIB) microscopy and machining.

The Bachelor Thesis may be written in either English or German.
For more information, please contact: **Cynthia Volkert** at the Institute of Materials Physics.

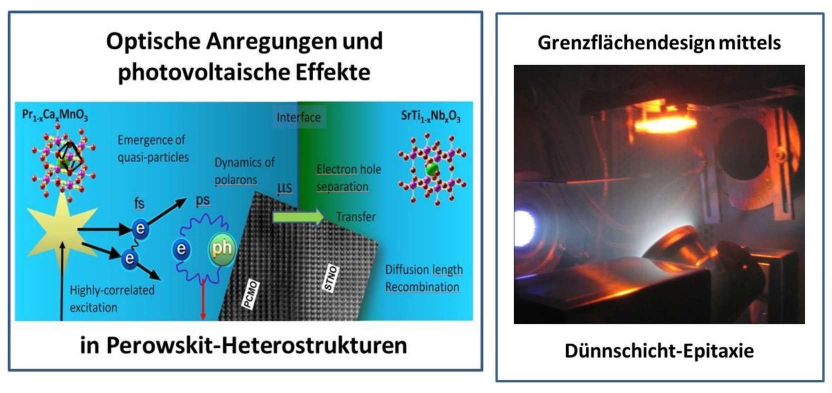
Ice needle grown under large applied voltage topped by snowflake grown without applied voltage (left, www.snowcrystals.com).

Cryogenic cooling holder for use in the electron/ion microscope (below, www.gatan.com).

Kontakt:
Prof. Cynthia Volkert,
volkert@ump.gwdg.de,
D.04.116, 39-25011

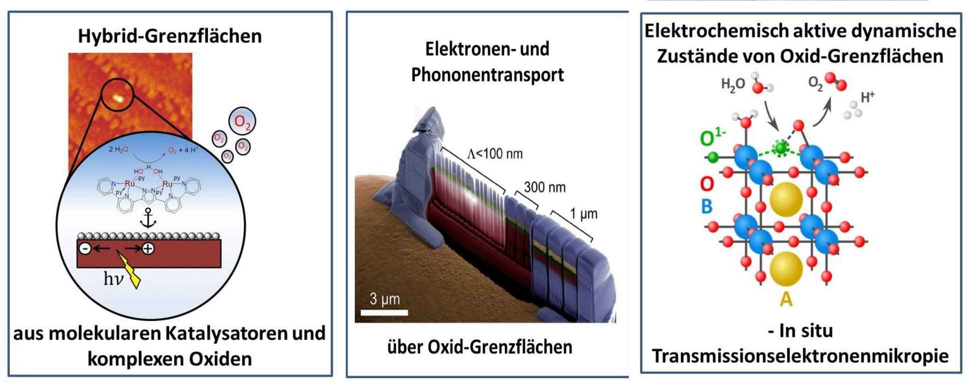
Nanoskalige multifunktionale Oxide

Was sind unsere Arbeitsgebiete?



Wenn Sie Interesse an einer Arbeit bei uns haben….

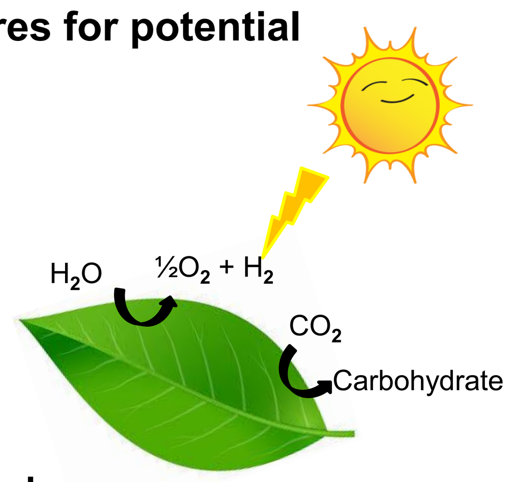
Prof. Christian Jooss
jooss@material.physik.uni-goettingen.de



Thema Bachelorarbeit:

Investigation of effect of carbon interlayer in the hybrid structures for potential application in artificial photosynthesis

- The **electrochemical reduction of CO_2** and **Oxidation of H_2O** which are key examples for multi-step charge transfer catalysis relevant to photosynthesis will be studied.
- Here, we will use a system consisting of catalytic unit and an absorber unit in order to achieve an **oxide-molecular hybrid system**.
- We will study the **effect of carbon interlayer on a oxide polaron absorbe** on two different **catalytic complexes**, i.e **Ru catalysts** and **Re complex**, both bearing pyrene anchoring groups.
- **X-ray Photoelectron Spectroscopy** and **Atomic Force Microscopy** will be used to characterize the molecular units on the surface.
- Further electrochemical investigation by **Rotating Ring Disk Electrode** will be done to study the stability, reactivity and catalytic performance of the hybrid system.

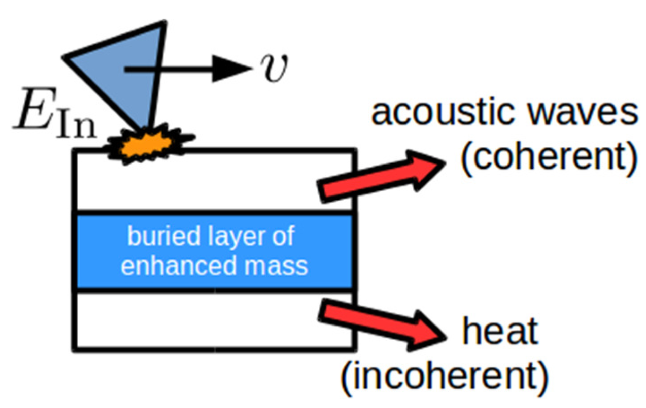


Contact: Dr. Fatemeh Ebrahimi
febrahi1@gwdg.de

Computer modeling of material properties

If you like to work numerically, i.e. with a computer, there are several options to do so at our institute. We mainly use Molecular Dynamics, the current focus being on dissipative processes (friction) occuring at the atomic scale.

A fundamental understanding of friction is still lacking. However, the **vibrational properties** of the substrate likely play an important role.



One possibility is to measure the **vibrational density of states** of several material structures (xtal, disordered, layered) using computer simulations.

Some of the things you could learn:
- Molecular Dynamics.
- High-performance computer hardware, numerical software libraries to deal with large matrices.

Kontakt: Dr. Richard Vink, rvink1@gwdg.de, D.03.119, 39-25030