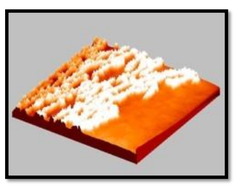
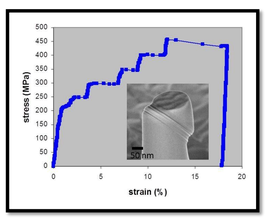
Bachelorarbeiten am Institut für Materialphysik

What do we study?



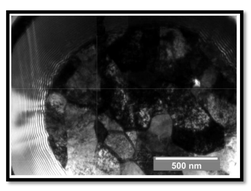
- What happens when you put hydrogen in a metal?
- What happens when you charge a battery?
- What happens during an electrocatalytic reaction?

- 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?

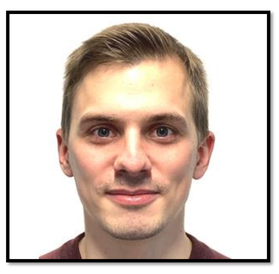
Then do your Bachelorarbeit with us!

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.



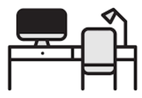
Electron Microscopy (Dr. Christine Borchers & Dr. Tobias Meyer): Owing to its high-resolution power, electron microscopy is a major tool in materials characterization. Furthermore, in combination, the scanning and transmission electron microscope bridge several orders of magnitude in real space and thus allow for obtaining a complete picture including meso- and microscopic effects down to the atomic level.

What do we offer our Bachelor students?

Due to Corona, there are currently some limitations

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.



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

Aktuelle Bachelorarbeiten

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

Determination of atomic structures by comparing experimental and simulated transmission electron microscope images ***(Meyer)***

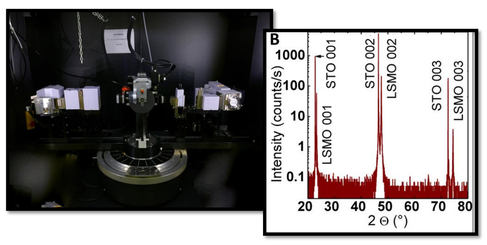
Untersuchung einer Messerklinge vor und nach dem Wetzen mittels SEM, TEM und Nanoindentation. ***(Borchers)***

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

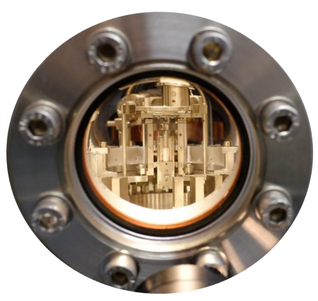
Preparation and Analysis of Insulating Layers for the 3ω-Method ***(Jooß)***

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



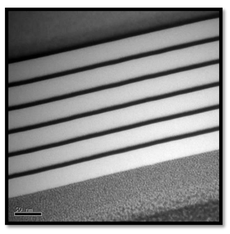
XRD apparatus with example measurement of an LSMO sample.



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.

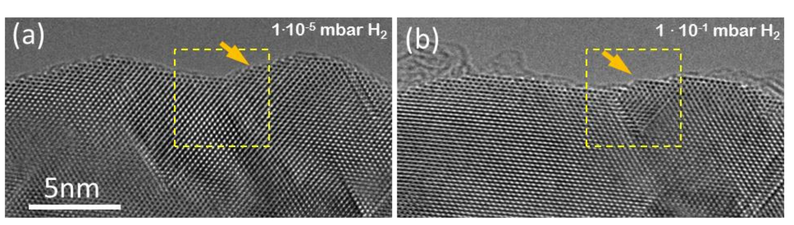


Thin Film Deposition: To understand how material properties depend on crystallographic structure, we need **high-quality samples** with very precise predefined structures. We are experts on creating such samples using a number of different vapor deposition methods. The picture shows a metal/polymer multilayer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

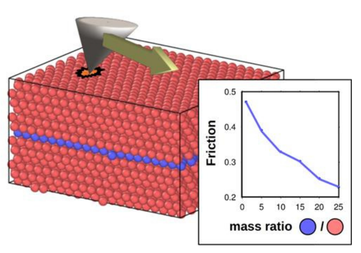
Atomic Scale Modeling: We routinely use computer simulations to complement experiments. Simulations provide detailed information, such as particle positions as a function of time, and help to understand phenomena occurring in real materials. The picture shows a molecular dynamics setup to study **nano-scale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

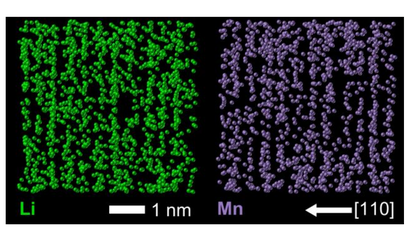
Titan 80-300 environmental atomic-resolution scanning / transmission electron microscope.

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 2021 / 2022

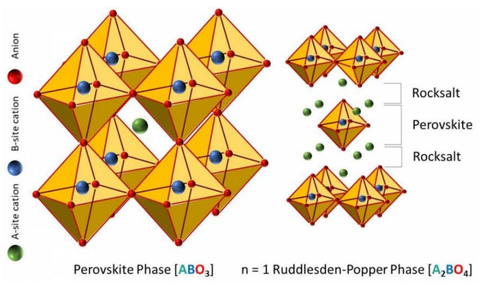
Zoom PDF

- If you are interested in our offered projects, please attend our online Zoom meeting on **Friday 3 December @ 13:00** or contact the responsible supervisor directly via E-Mail.
- This poster is also available for download at our institute website, under the Section **Lehre**.

Pulsed Laser Deposition

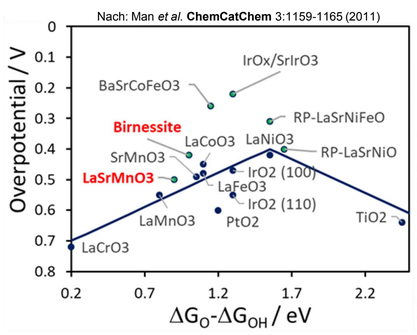
Mit Hilfe der gepulsten Laserdeposition (PLD) stellen wir dünne Schichten im Bereich weniger Nanometer bis hin zu Mikrometern mit **hoher Qualität** her. Hierbei können wir durch die Wahl der Prozessparameter die **Eigenschaften der Schichtsysteme** wie z.B. Struktur, Rauheit oder Zusammensetzung gezielt **beeinflussen**.

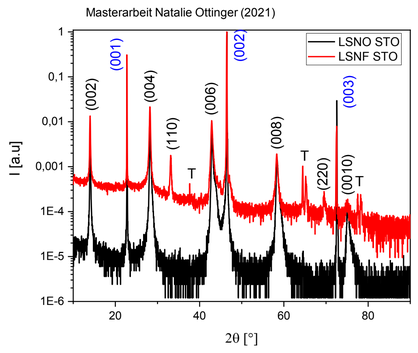
Bei der Energiekonversion und -speicherung spielen die Materialklasse der Perowskite und deren Ruddlesden-Popperphasen - ihre 2D-Variante - eine zentrale Rolle, denn sie können z.B. Basis von organischen und anorganischen Solarzellen, Katalysatoren und Batteriematerialien sein.

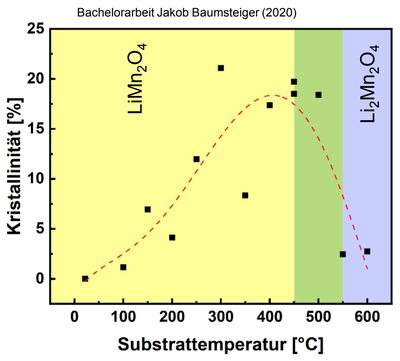


Mögliche Bachelor Projekte:

1. **Wachstums-Optimierung des Elektrokatalysten $LaSrNi_{1-x}Fe_xO_4$**
2. **Epitaktisches Wachstum des Batteriematerials $LiMn_2O_4$**



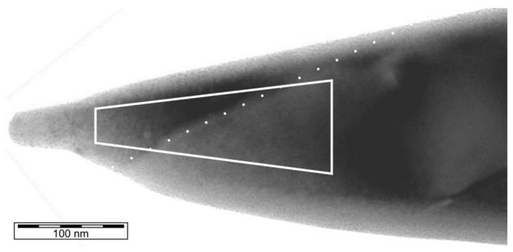




Kontakt: Dr. Sarah Hoffmann-Urlaub, shoffma3@gwdg.de, D02.120, 39-29642

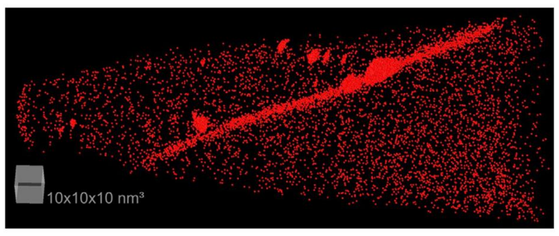
Preparation of atom probe samples at a grain boundary

Grain boundaries play a key role in multiple fields of interest for our group, such as ion transport in ionic conductors or hydrogen in steel. The preparation of atom probe samples with a grain boundary in the measurable volume has several unique challenges. Within this project you will work with a Focused Ion Beam Microscope to develop a preparation routine for atom probe samples at a grain boundary and use a Transmission Electron Microscope to verify the produced samples.



Grain boundary in a $LiMn_2O_4$ sample.

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



Segregation of Na at the grain boundary.

Nanoskalige multifunktionale Oxide

Was sind unsere Arbeitsgebiete?

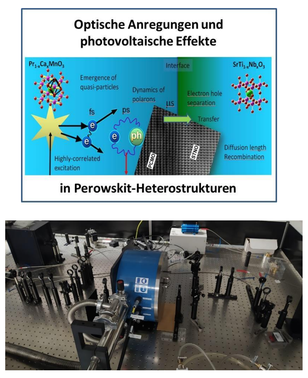
- *Was bestimmt in komplexen Oxiden atomare und elektronische Struktur von Grenzflächen und damit auch die Entstehung neuartiger Eigenschaften?*
- *Wie können Mechanismen der Energiewandlung in stark korrelierten nano-skaligen Oxiden verstanden und nutzbar gemacht werden?*
- *Welche Verfahren eignen sich zum Design von Grenzflächen und Nanostrukturen in komplexen Oxiden auf atomarer Skala?*

Wenn Sie Interesse an einer Arbeit bei uns haben….

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

Thema Bachelorarbeit: ZnO (geplanter Beginn, April 2022)

- ZnO ist ein Material, welches in der aktuelle Forschung bzgl. seiner vielfältigen opto-elektronischen Eigenschaften intensiv untersucht wird.
- In Rahmen dieser Bachelorarbeit soll Mn-dotiertes ZnO in Form dünner Filme mittels Ionenstrahlsputtern hergestellt werden.
- Untersucht wird zunächst das epitaktische Wachstum der Filme auf Saphir, d.h. bei welchen Depositionsbedingungen erhält man qualitativ hochwertige, einkristalline Filme. Die Untersuchungen erfolgen dabei mittels Röntgenbeugung.
- Die hergestellten Filme sollen weiter bzgl. der elektrischen Leitfähigkeit charakterisiert durch temperaturabhängige Widerstandsmessungen charakterisiert werden.



Thema Bachelorarbeit: Absorption in Perowskiten

- In dieser Arbeit soll die optische Absorption in Manganaten untersucht werden. Diese gibt Aufschluss über die verschiedenen Absorptionsmechanismen, die abhängig von der Photonenenergie auftreten.
- In unserer Arbeitsgruppe untersuchen wir komplexe Oxidmaterialien wie die Manganate im Hinblick auf alternative Mechanismen für die photovoltaische Energiekonversion, für die ein Verständnis der spektral aufgelösten Absorption essentiell ist.
- Hierfür verwenden wir einen neu entwickelten Messaufbau der auch Tieftemperaturmessungen erlaubt (siehe Bild).
- **Bei Fragen zu dieser Arbeit: stephan.melles@uni-goettingen.de**

Hydrogen Charging and Characterization of bulk Steel Samples

On the way to a zero-emission economy based on hydrogen as energy carrier, some obstacles are to overcome [1, 2]. One is hydrogen induced cracking and brittle failure of materials well below the yield stress of the respective pristine material, an effect known as hydrogen embrittlement (HE) [3].

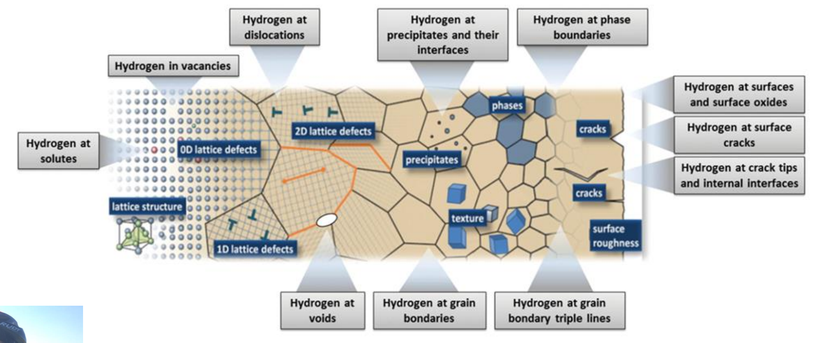
To unravel the microstructural origin of HE, a Phd student at our institute, Jonas Arlt, is working on atomically resolved detection of hydrogen within steel samples containing a chosen microstructure of interest by atom probe tomography (APT). The APT samples need to be charged with hydrogen from the gaseous phase before the experiment within a separate loading chamber.

The task of the bachelor student would be to use the existing loading chamber to load pristine bulk steel samples as well as samples covered with a thin (< 15 nm) catalytic Ni surface layer with hydrogen and to characterize the amount of charging by thermal desorption spectroscopy (TDS) under different loading conditions (e.g. temperature, gas pressure).

Besides the coating technique (electron beam induced thermal evaporation and subsequent deposition) and TDS the student would get insights in transmission electron microscopy (TEM) and APT whilst working in strong collaboration with the Phd student and technical staff of the IMP.

References:

[1] Züttel A, Remhof A, Borgschulte A, Friedrichs O. *Hydrogen: the future energy carrier*. Phil Trans Roy Soc A 2010 368:3329-3342. https://doi.org/10.1098/rsta.2010.0113
[2] Crabtree GW, Dresselhaus MS, Buchanan MV. *The Hydrogen Economy*. Phys Today 2004 57:39-44.
[3] Robertson IM, Sofronis P, Nagao A, Martin ML, Wang S, Gross DW, Nygren KE. *Hydrogen embrittlement understood*. Metall Mater Trans B 2015 46:1085-1103. https://doi.org/10.1007/s11663-015-0325-y



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