Modulbezeichnung:	**Fundamentals of Micro- and Nanostructure Research NT (IMN_M6-NT)** (Fundamentals of Micro- and Nanostructure Research NT)	**10 ECTS**
Modulverantwortliche/r:	Erdmann Spiecker	
Lehrende:	Benjamin Apeleo-Zubiri, Johannes Will, Erdmann Spiecker, Stefanie Rechberger, Mingjian Wu	

Startsemester: WS 2020/2021	Dauer: 2 Semester	Turnus: jährlich (WS)
Präsenzzeit: 120 Std.	Eigenstudium: 180 Std.	Sprache: Deutsch und Englisch

Lehrveranstaltungen:

Übungen zur Transmissionselektronenmikroskopie 1 (WS 2020/2021, Übung, 2 SWS, Mingjian Wu et al.)

Transmissionselektronenmikroskopie in Materialforschung und Nanotechnologie 2 (SS 2021, Vorlesung, 2 SWS, Erdmann Spiecker et al.)

Übungen zur Transmissionselektronenmikroskopie 2 (SS 2021, Übung, 2 SWS, Mingjian Wu et al.)

Rasterelektronenmikroskopie in Materialforschung und Nanotechnologie (WS 2020/2021, Vorlesung, 2 SWS, Erdmann Spiecker et al.)

Inhalt:

The module deals with the fundamentals of micro- and nanostructure research with the focus on today's state-of-the art capabilities of transmission electron microscopy in the investigation of materials down to the atomic scale. The module begins (TEM 1 exercise, and TEM 1 lecture as part of the M1 Pflichtmodul) with the basic physics of fast electrons, their generation and guidance by electromagnetic fields and their interaction with matter in the specimen and the detector. Afterwards various imaging (BF, DF, HRTEM, STEM), diffraction (ED, CBED), spectroscopic (EDXS, EELS, EFTEM) and 3D (ET) techniques including their applications to current research topics will be introduced. The aim is always to give insight into both the contrast mechanisms and physics of as well as the achievable information delivered by the different techniques.

The module furthermore focuses on the introduction to Scanning Electron Microscopy (SEM) in Materials Science and Nanotechnology. Amongst others, the following topics are addressed: - Components of an SEM instrument - Elastic/inelastic electron-probe/sample interactions, interaction volume, generation of secondary and backscattered electrons - Contrast mechanisms of different detector systems - Topographic und chemically-sensitive imaging - Electron diffraction and its application in SEM - Scanning Transmission Electron Microscopy (STEM) - Quantitative X-ray spectroscopy - Focused ion beams (Dual-Beam FIB, He-ion microscopy) - Preparation-specific challenges - Application examples.

Lernziele und Kompetenzen:

Die Studierenden

Fachkompetenz

Wissen

SEM lecture:

- Introduction to the basic concepts of and physics behind SEM

TEM 1 & 2 exercise and TEM 2 lecture in addition to TEM 1 lecture (from M1 Pflichtmodul):

- Basic concepts of the interaction of fast electrons with matter
- Introduction of TEM components and their functionality
- Knowledge about the application of high resolution techniques for nanomaterials

Verstehen

SEM lecture:

- Overview over applications and deeper understanding of SEM and FIB techniques in materials science on the micro- and nanoscale
- Enhancement of knowledge through teaching of current SEM applications and state-of-the-art developments in research

TEM 1 & 2 exercise and TEM 2 lecture in addition to TEM 1 lecture (from M1 Pflichtmodul):

- In-depth understanding of microscopy techniques for micro- and nanostructure research

- In-depth understanding of basic and advanced imaging, diffraction and spectroscopic TEM techniques and their application to material science

Anwenden

TEM 1 & 2 exercise:

- Hands-on-training on modern analysis software for EM applications
- Each topic will be accompanied with suitable exercises

Analysieren

- Insight into the structure property relationship of materials

Literatur:

TEM:

- Goodhews, Humphreys and Beanland: Electron Microscopy and Analysis;
- Williams & Carter: Transmission Electron Microscopy;
- Reimer & Kohl: Transmission Electron Microscopy;
- Fultz & Howe: Transmission Electron Microscopy and Diffractometry of Materials;
- Reimer: Transmission Electron Microscopy;
- De Graef: Introduction to Conventional Transmission Electron Microscopy;
- Reimer: Scanning Electron Microscopy;
- P. Haasen: Physikalische Metallkunde;
- G. Gottstein: Physikalische Grundlagen der Materialkunde;
- J. M. Cowley: Diffraction Physics

SEM:

- Reimer, Scanning Electron Microscopy, Springer Verlag. - Goodhews, Humphreys and Beanland: Electron Microscopy and Analysis - Goldstein et al., Scanning Electron Microscopy and X-Ray Microanalysis (2003) - N. Yao, Focused Ion Beam Systems, Basics and Applications, Cambridge University Press, 2010. - L.A. Gianuzzi, F.A. Stevie, Introduction to Focused Ion Beams. Instrumentation, Theory, Techniques and Practice, Springer, 2005. - J. Orloff, M. Utlaut, L. Swanson, High Resolution Focused Ion Beams: FIB and its Applications, Springer, 2003 - Lecture notes.

Verwendbarkeit des Moduls / Einpassung in den Musterstudienplan:

Das Modul ist im Kontext der folgenden Studienfächer/Vertiefungsrichtungen verwendbar:

[1] **Nanotechnologie (Master of Science)**

(Po-Vers. 2020w | TechFak | Nanotechnologie (Master of Science) | Gesamtkonto | Kernfächer | Mikro- und Nanostrukturforschung | Fundamentals of Micro- and Nanostructure Research NT)

Studien-/Prüfungsleistungen:

Fundamentals of Micro- and Nanostructure Research (Prüfungsnummer: 62911)
(englische Bezeichnung: Fundamentals of Micro- and Nanostructure Research)

Untertitel: NT Prüfungsleistung, mündliche Prüfung, Dauer (in Minuten): 30
Anteil an der Berechnung der Modulnote: 100%
weitere Erläuterungen:
Prüfungssprache nach Wahl der Studierenden
Prüfungssprache: Deutsch oder Englisch

Erstablegung: SS 2021, 1. Wdh.: WS 2021/2022
1. Prüfer: Erdmann Spiecker
