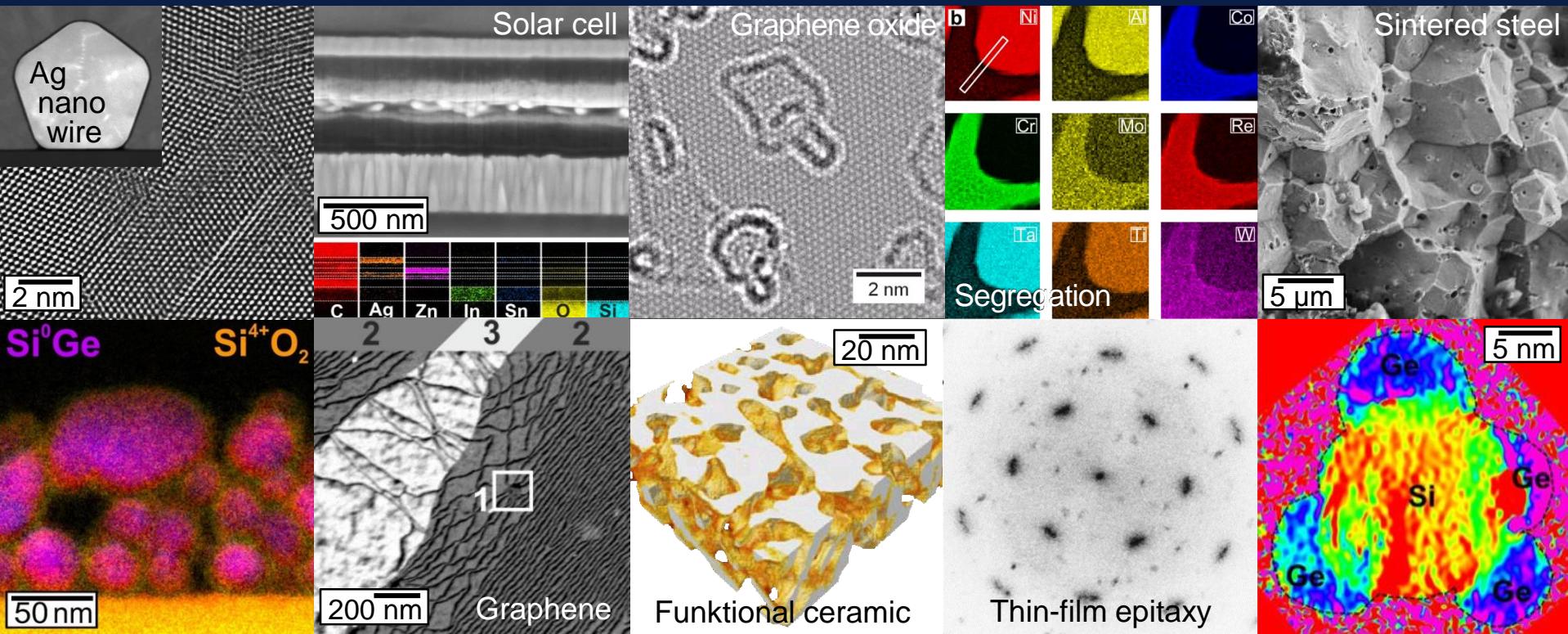


# Mikro- und Nanoanalytik in der Materialforschung

Prof. Dr. Benjamin Butz



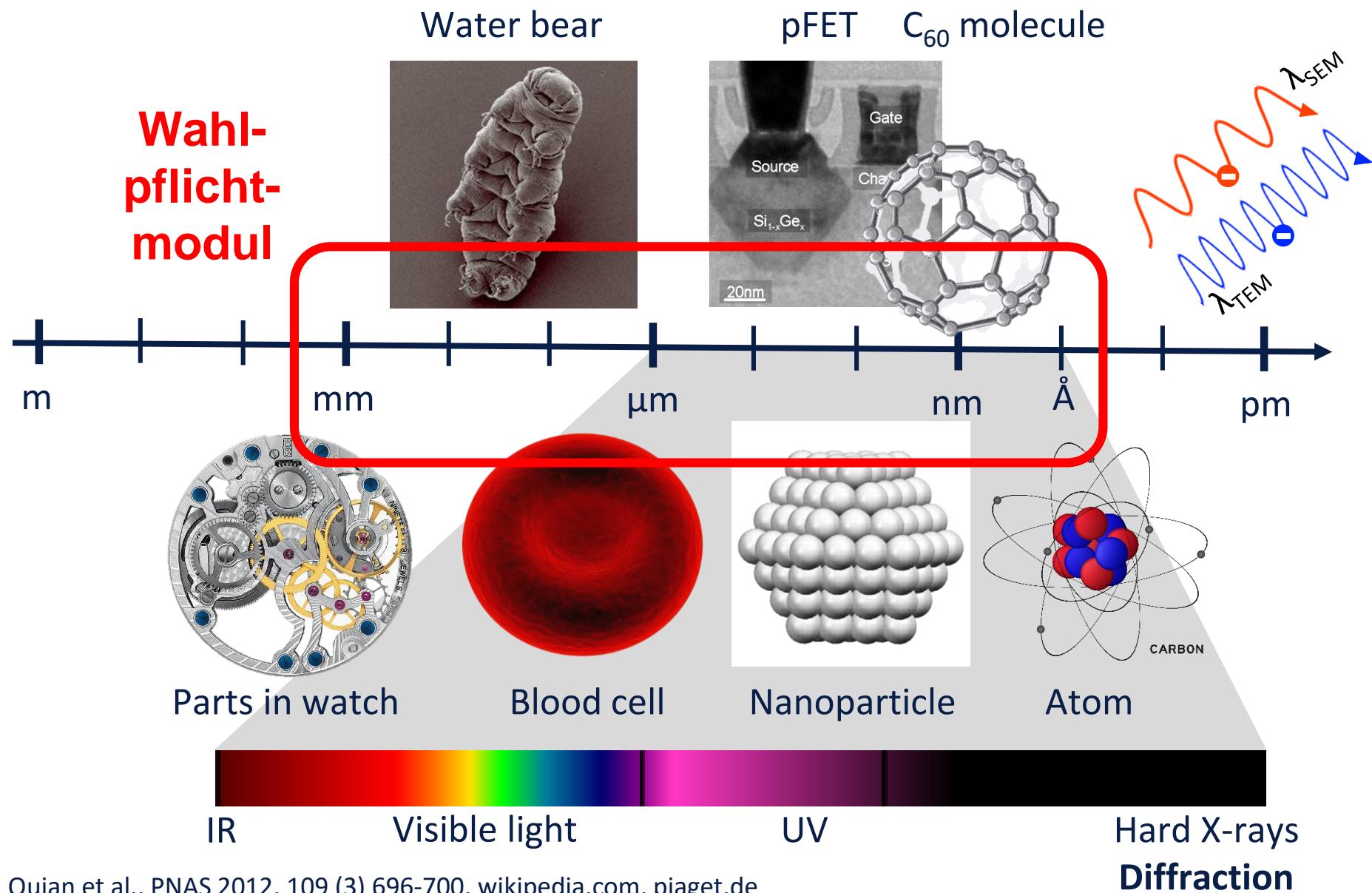
Micro- and Nanoanalytics & –Tomography Group  
University of Siegen, Germany



Materialcharakterisierung mit  
**modernsten Methoden der**  
**Elektronen- und Ionenmikroskopie**  
von der mm-Skala bis auf die atomare Ebene

- Schadensanalytik
- Materialentwicklung
- Grundlagenforschung
- Methodenentwicklung

# Size Scales



# Micro- and Nanoanalytics in Materials Science

SEM ( $-30$  kV)

## Scanning electron & ion microscopy (SS)

Electron sources, lenses, aberrations, resolution  
Interaction electron — atom, in-/elastical scattering  
Contrast mechanisms — detectors  
X-ray excitation, detection  
Recent developments + new techniques  
ion-beam microscopy

+ Lab course

TEM (60–300 kV)

## TEM & electron diffraction (SS)

Electron sources, lenses, aberrations, resolution  
Interaction electron — atom, in-/elastical scattering  
Electron diffraction, diffraction-contrast imaging:  
microstructure, defects

+ Lab course

## Advanced TEM and spectroscopy (WS)

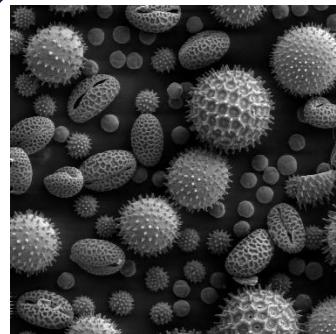
High-resolution (S)TEM (HR(S)TEM)  
Electron holography, tomography  
Analytical techniques (EDXS, EELS)

### Prospective courses starting SS19, WS19/20

- Scattering techniques & tomography
- Complementary nanocharacterization (scanning probes, ...)

# SEM / FIB Methods

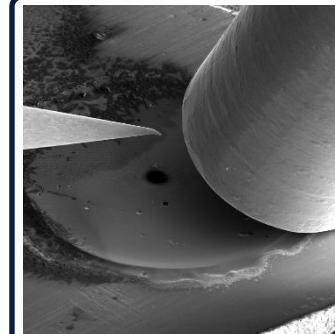
## Conventional imaging



- Topography
- Z-contrast
- Electric/magnetic fields

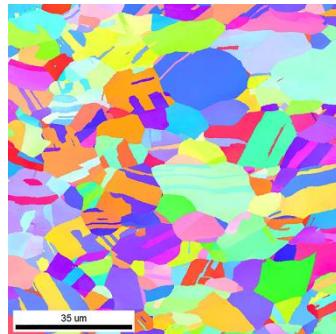
SEM/  
FIB

## Cutting / manipulation



- TEM-sample preparation
- Manipulation
- Depth profiling
- Imaging

## EBSD

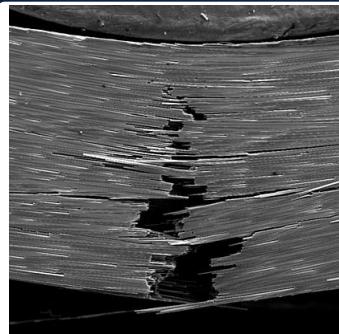


- Crystal structure
- Microstructure
- Strain

[gatan.com](http://gatan.com)



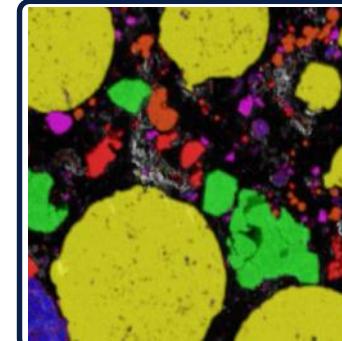
## In situ microscopy



- Mechanical/electrical testing
- Heating
- Cooling
- Environment

[kammlath&weiss](http://kammlath-weiss.de)

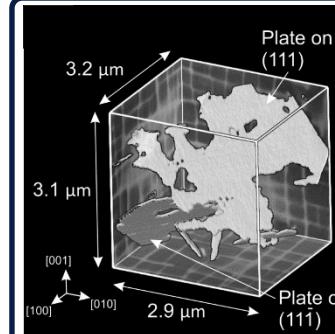
## Chemical analysis



[fei.com](http://fei.com)

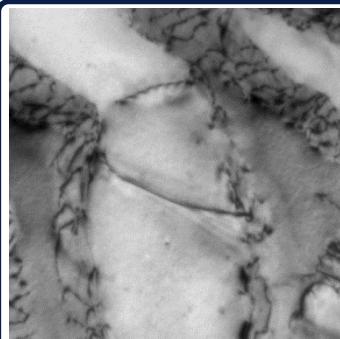
- Composition
- Combination EBSD / EDS

## Tomography



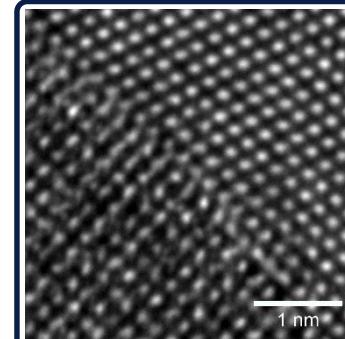
- 3D morphology
- 3D chemistry
- Phase/pore distributions

## Conventional imaging



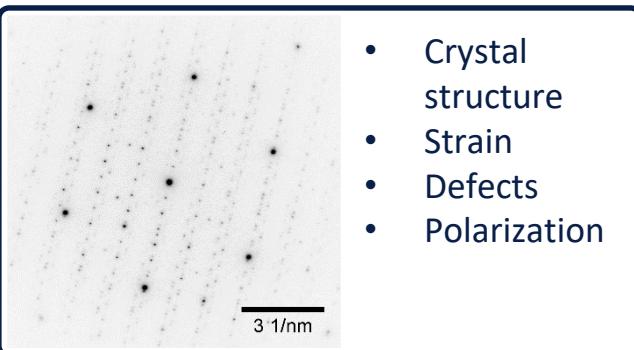
- Morphology
- Dislocations
- Stacking faults
- Micro-structure

## High-resolution imaging



- Atomic structure
- Interfaces
- Strain
- ...

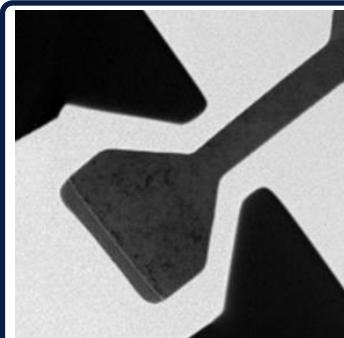
## Electron diffraction



- Crystal structure
- Strain
- Defects
- Polarization



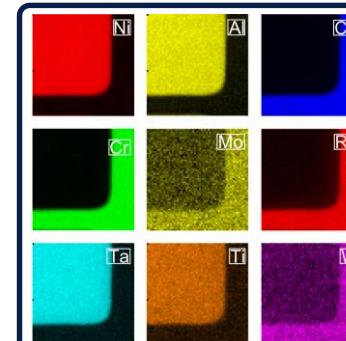
## In situ microscopy



- Mechanical/electrical testing
- Heating
- Cooling
- Environment

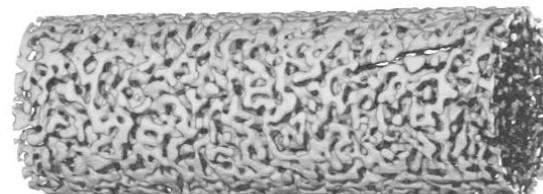
Hysitron

## Chemical analysis



- Composition
- Bonding
- Oxidation state

## Tomography



- 3D structure
- 3D chemistry