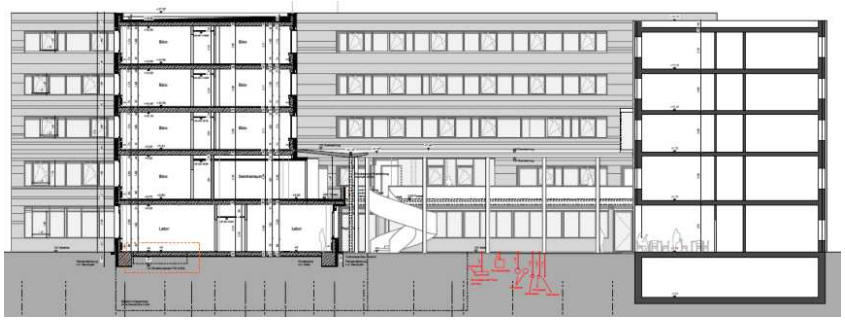
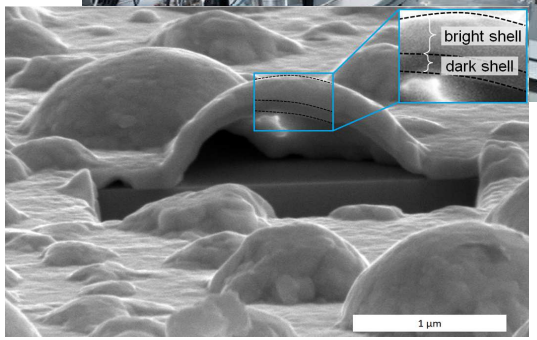
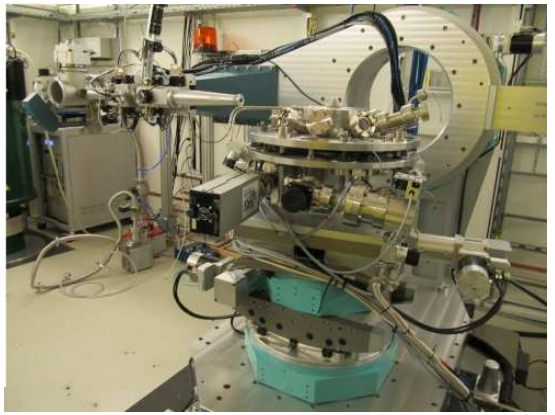
# Management of Nanotechnology Laboratory as a RI









**Andreas Stierle**

**DESY FS-NL and University of Hamburg (INF)**

HELMHOLTZ ASSOCIATION

**http://nanolab.desy.de/**

UHH

DESY.

# The DESY NanoLab Team

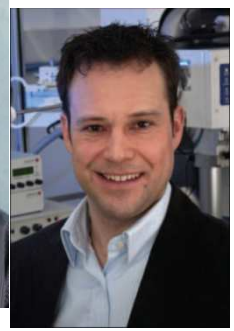
## Scientists

Thomas Keller

Vedran Vonk

Heshmat Noei

Andreas Stierle



## Postdocs

Mike Wagstaffe

Simon Chung

Elin Granaes

Arti Dangwal-Pandey

## Guests

Mikhail Shipilin (Stockholm University)




## PhD & Master students

Konstantin Krausert

Primin Lakner, Steffen Tober

Henning Runge

Guilherme dalla Lana

Björn Arndt Marcus Creutzburg

Robert Gleissner

## Administrative & Technical support

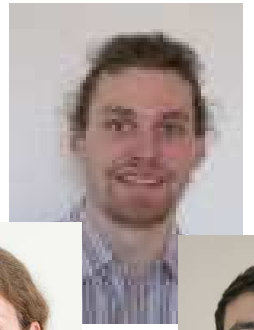
Katharina Roeper

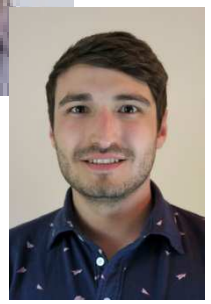
Simon Geile

Satish Kulkarni

Arno Jeromin

Dennis Renner



# Mission of the DESY NanoLab

**Providing on-site methods for nanoscience complementary to DESY photon techniques at PETRA III, FLASH and X-FEL especially for experiments with nano-focussed beams**

**Open for:**

- external users in the framework of accepted proposals or “around” beamtimes
- Support of DESY and campus wide in-house research (collaborative / contributive level)
- European users in the framework of access program nano + x-rays NFFA EUROPE (Nano Foundaries and Fine Analysis)
- X-FEL users on collaborative level, full access depending on negotiations with X-FEL GmbH

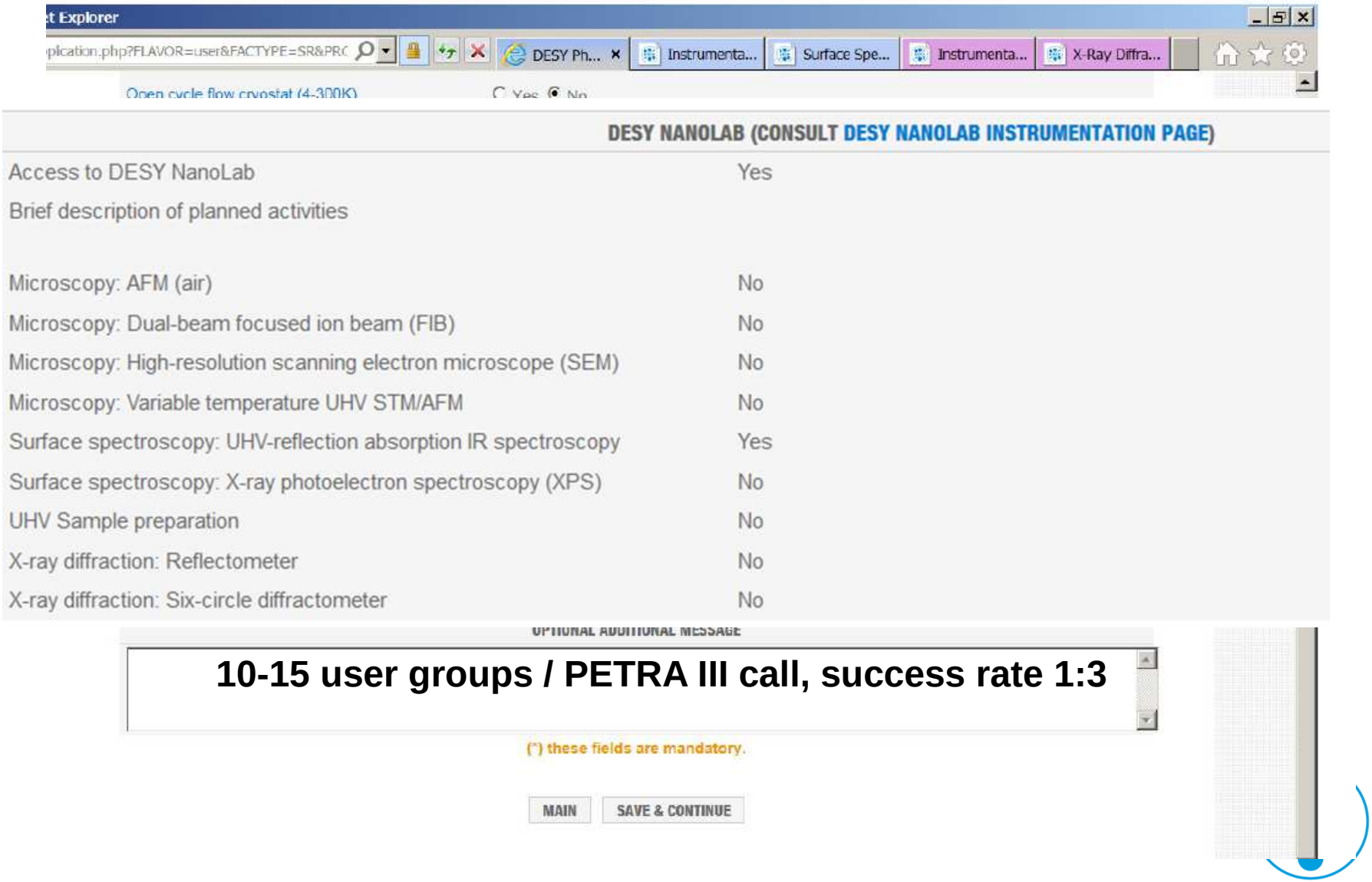
# DESY NanoLab Location


http://desy.de/~videoweb/cxns/aktuell.html

DESY Site – Campus Bahrenfeld

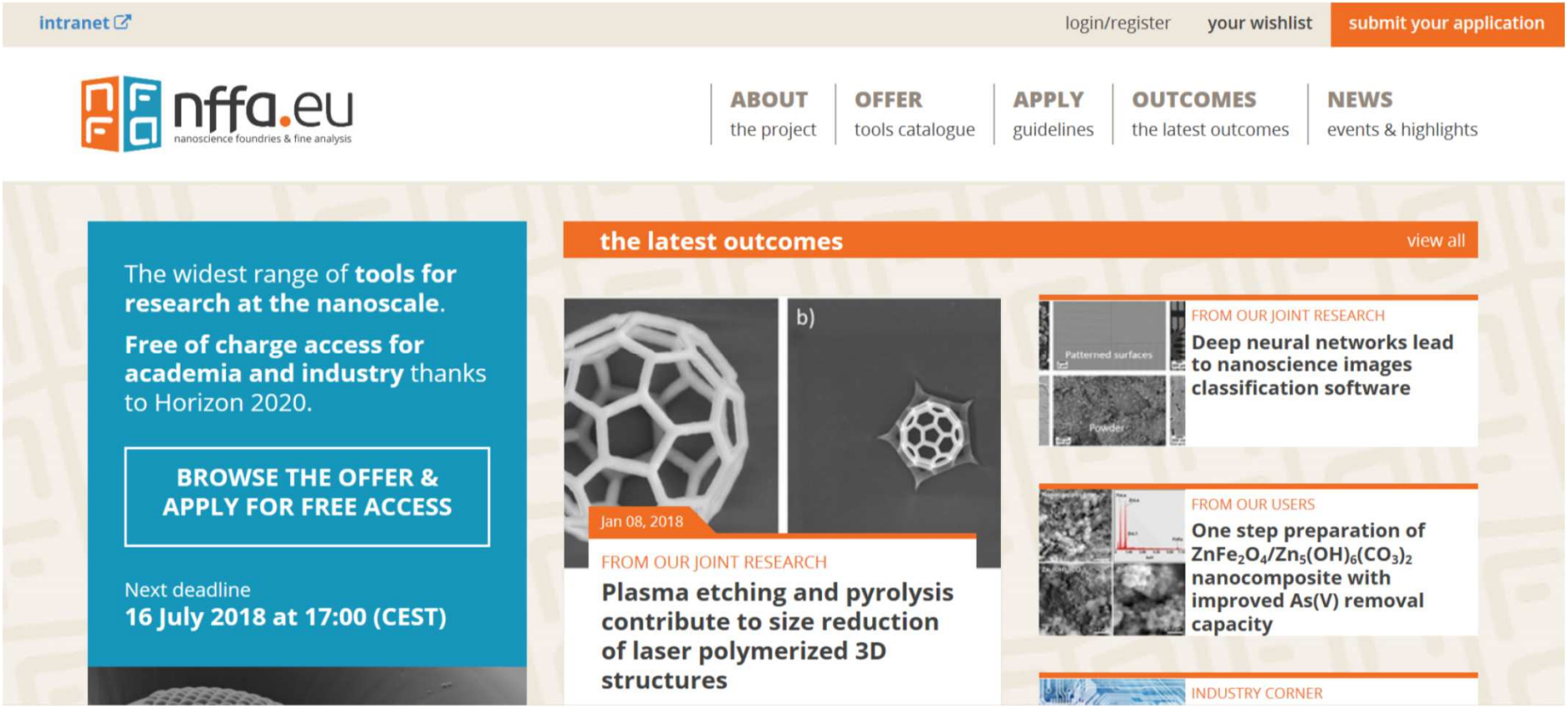
# How to Access the DESY NanoLab

## 1. DESY NanoLab box in „DOOR“ for beamtime proposals



# How to Access the DESY NanoLab

## 2. European access project NFFA



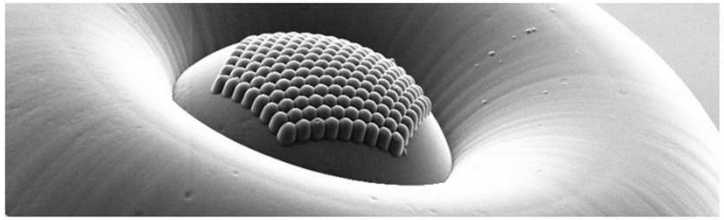

**DESY NanoLab methods + beamtime at PETRA III**
**www.nffa.eu, questions: thomas.keller@desy.de**

# 2. European access project NFFA

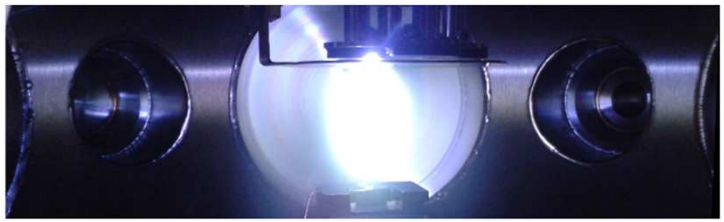
nffa.eu
nanoscience foundries & fine analysis

Regulated access to state of the art nanoscience facilities

Integrated with the large scale infrastructures for fine analysis

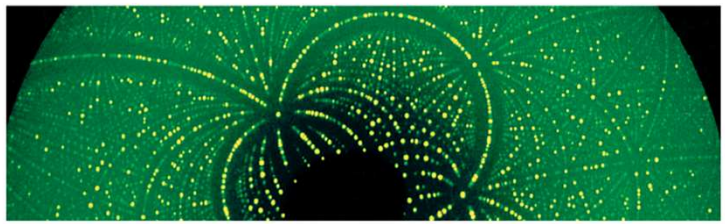


**LITHOGRAPHY & PATTERNING**



**GROWTH & SYNTHESIS**

**THEORY & SIMULATION**



**CHARACTERISATION**

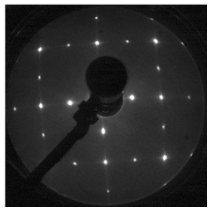


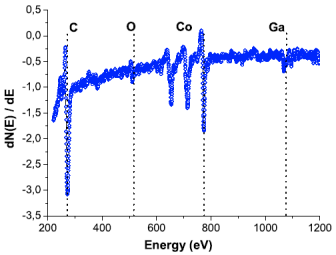
DESY.

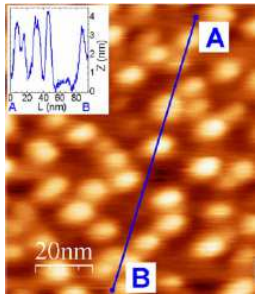
# DESY NanoLab Strategy

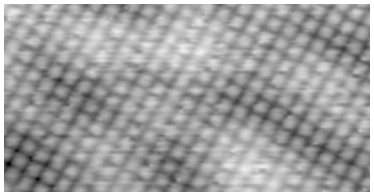
**Implementation of**

- nano characterization techniques (atomic scale structure, chemistry and magnetism)
- nano structuring techniques
- nano synthesis techniques

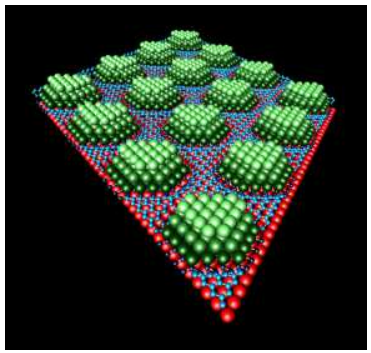


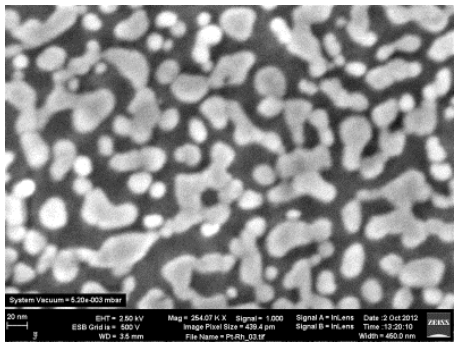


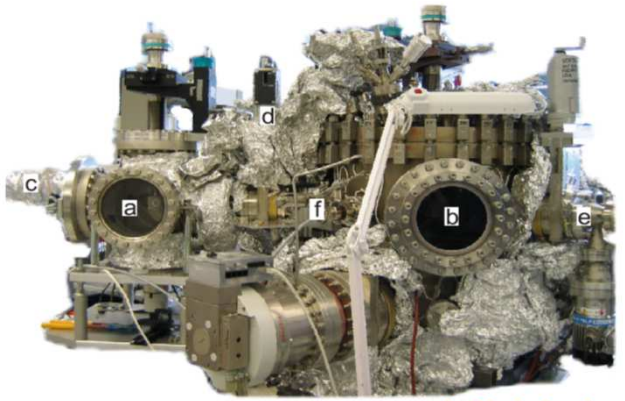



**Development of well defined sample transfer protocols between NanoLab and beamlines (nano-PS)**



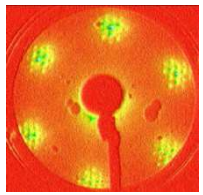


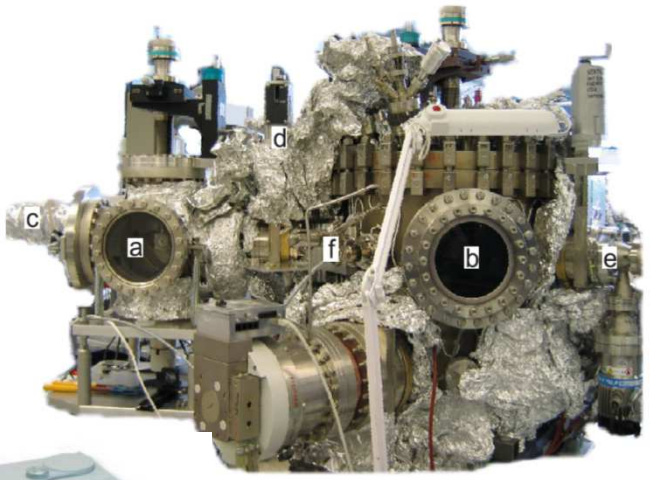


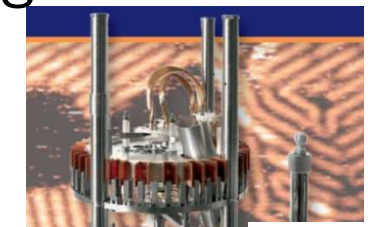
# Overview DESY NanoLab Techniques

## Spectroscopy & Growth (H. Noei)

- UHV sample preparation chambers with LEED / AES
- XPS, FT-IR, STM





## X-ray diffraction (V. Vonk)

- Reflectometer
- Six circle diffractometer

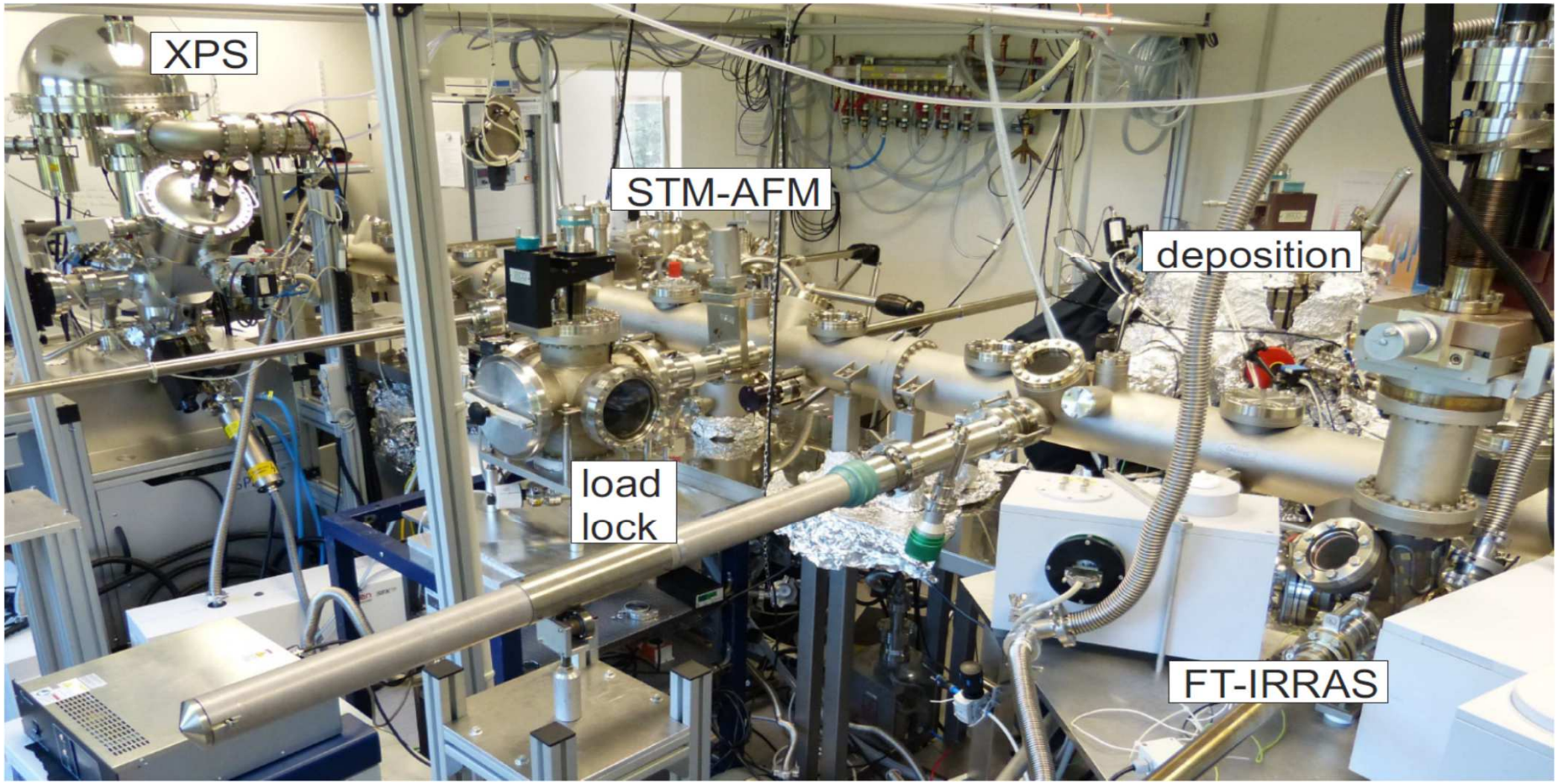
## Microscopy & Structuring (T. Keller)

- AFM, STM, optical
- SEM + FIB + Lithography (future)


## Magnetic Characterization (R. Röhlsberger)

- Physical properties measurement system (CHyN)
- Kerr Microscope (future)

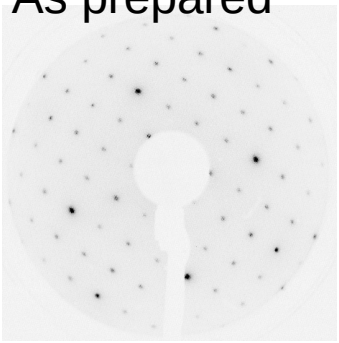
# UHV Lab: Structure, Composition and Growth



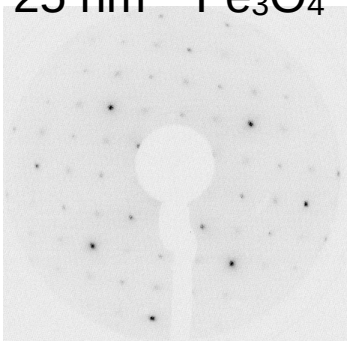

**Multi method UHV laboratory**

# UHV Lab: Structure, Composition and Growth

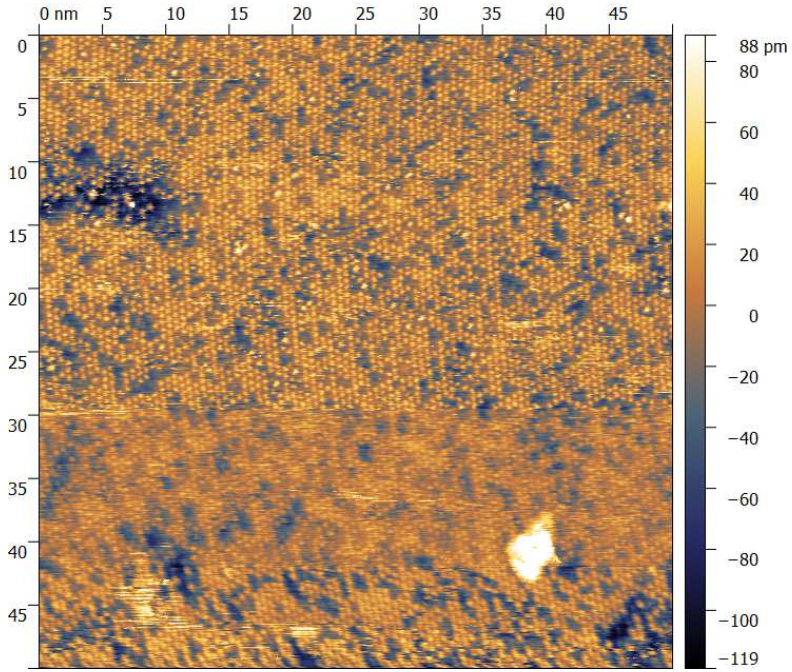
As prepared



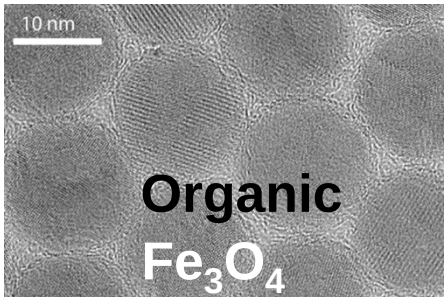
25 nm $^{57}Fe_3O_4$

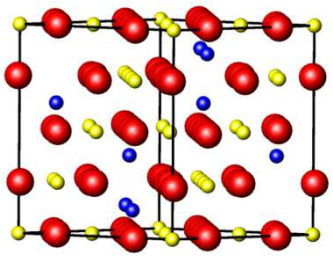


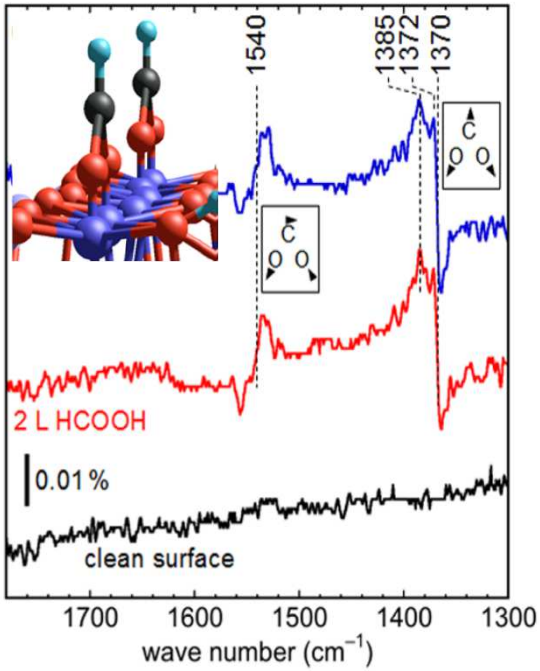
LEED-patterns before and after growth of 25 nm $^{57}Fe_3O_4$ (S. Tober)




FT-IR spectroscopy of formic acid on magnetite (001), XPS: oxidation state






O. Gamba, H. Noei, A. Stierle, *et al.*, J. Phys. Chem. C 119, 20459 (2015)
A. Dreyer,..,H.Noei, A. Stierle, et al., Nature Materials 15 522-528 (2016)

STM on magnetite (111)
M. Creutzburg, E. Granäs, SFB 986, TU HH

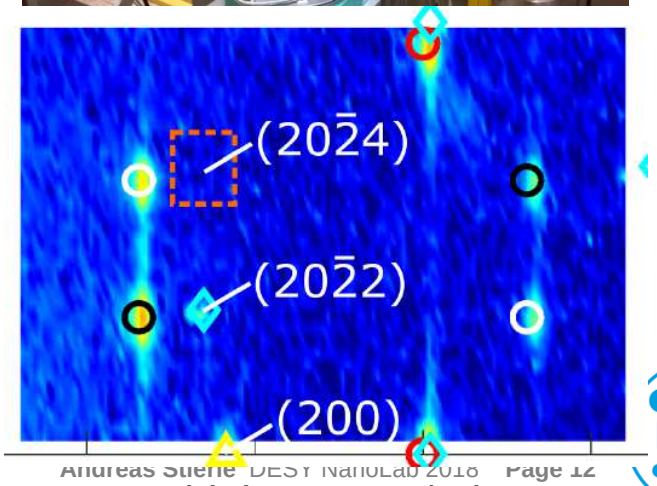
# X-ray diffraction & Sample Environments

**Reflectometer:** ***Roughness, film thickness***

- **Source: Mo-$K_\alpha$**
- Spot size: 12×0.3 $mm^2$ (h×v)
- Divergence: 0.4 $mrad^2$ (v)
- **Type: θ-2θ scans**
- Control software: SPEC
- Detectors: Point detector, Strip detector (Mythen)

**Diffractometer:** ***Crystallinity, crystal phases and orientations***

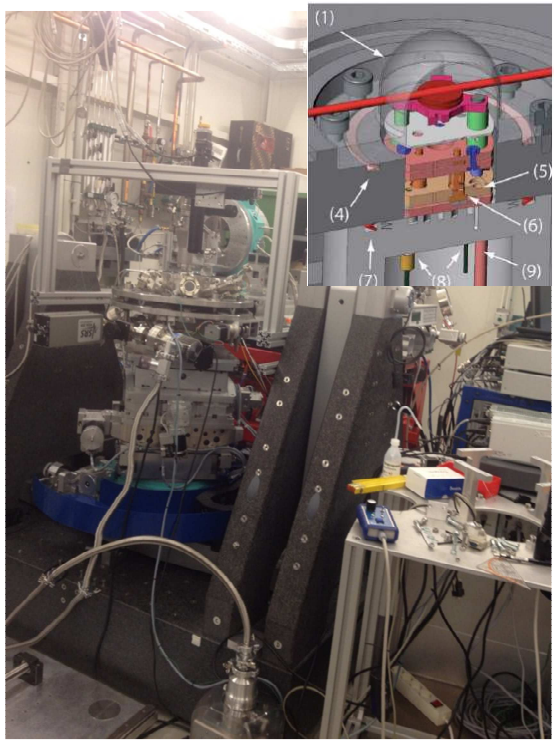
- **Source: Cu-$K_\alpha$**
- Spot size: 0.25×0.25 $mm^2$ (h×v)
- Divergence: 5x5 $mrad^2$ (h×v)
- **Type: full reciprocal space access**
- Control software: SPEC
- Detectors: Point detector or Strip detector (Mythen)



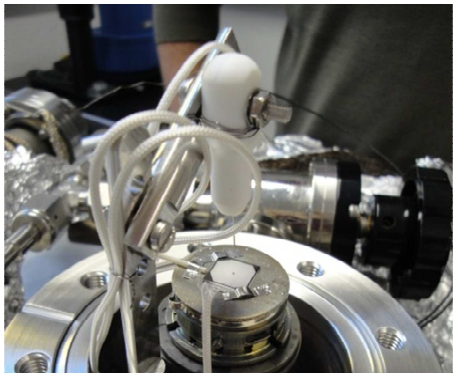

2.6 nm high Pt NPs / $Al_2O_3$

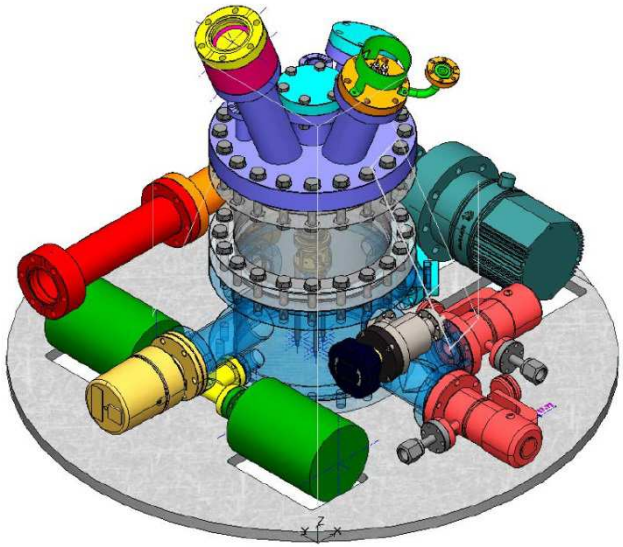
# X-ray diffraction & Sample Environments

## Mobile in-situ X-ray Diffraction Sample Environments

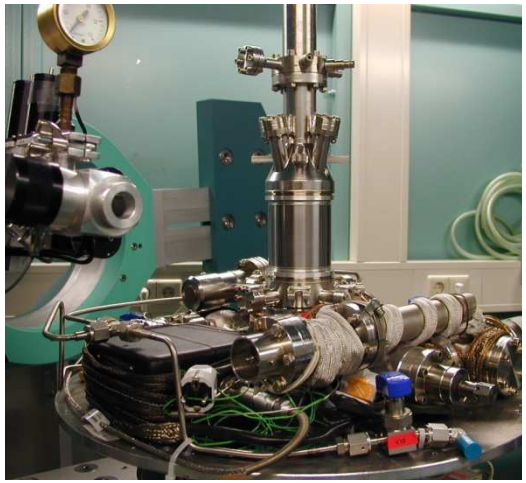



In-situ UHV / flow reaction chamber (BMBF NanoXcat) for catalysis





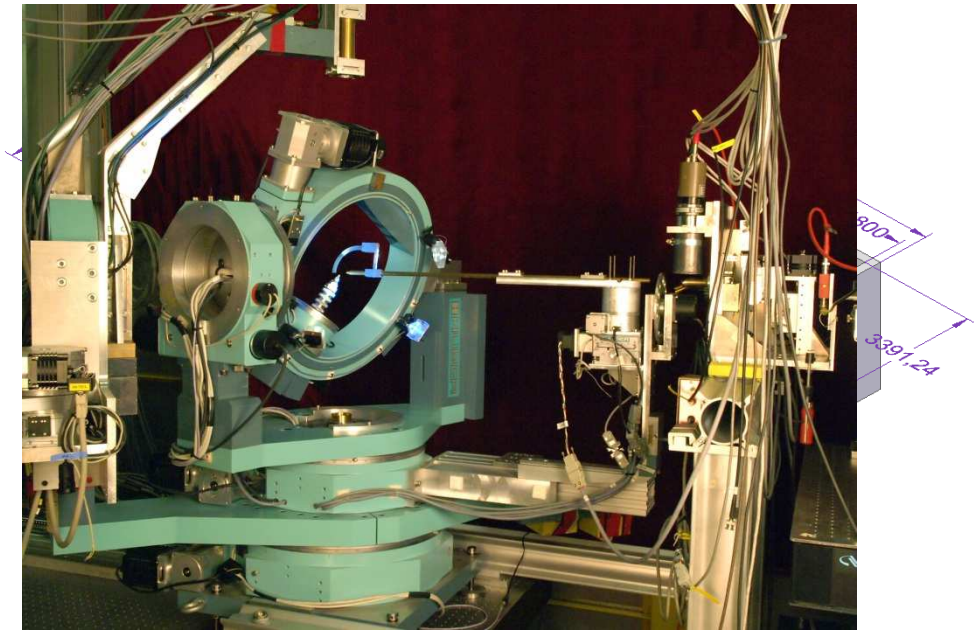
In-situ solid state electrochemistry Chamber, EC cells



In-situ UHV / HP chambers
RT-900 K
UHV - 1 bar
RT- 1500 K
UHV – $10^{-4}$ mbar

# X-ray Diffraction & Sample Environments

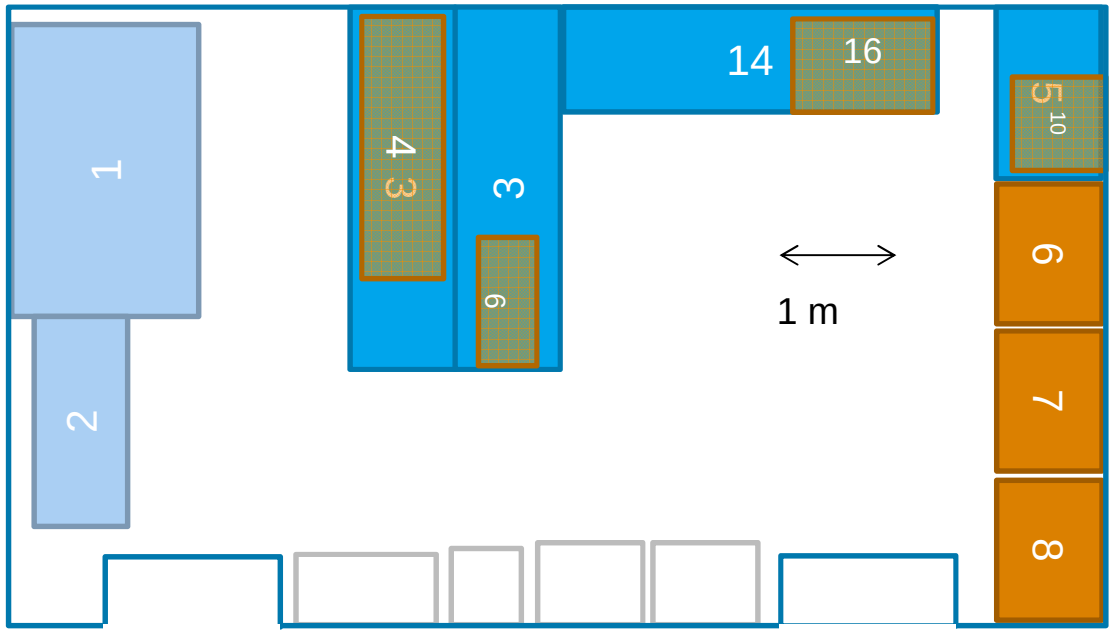
## Future location: DORIS hall building 25




1. Reflectometer
2. Six circle diffractometer (z axis style) (GIXRD, SXRD)
3. Six axis diffractometer (with Eulerian craddle), old Weckert instrument (GISAXS, GIXRD)

# X-ray Diffraction & Sample Environments

## Future Electrochemistry laboratory in building 25b




In cooperation with CAU Kiel, Ruprecht Haensel Labor

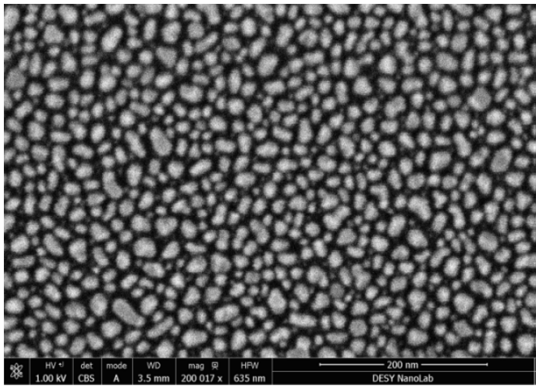
- Vakuumsysteme
- Labormöbel
- Abzüge
- Geräte auf Laborbänken
- Lager

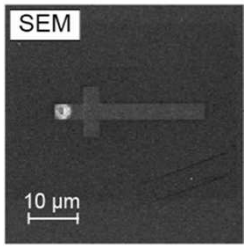
1. UHV System (Präparationskammer, Transfersystem, Rack) 2.6 m x 1.6 m (4.0 $m^2$) / Nanolab
2. Glovebox Elektrochemie 1.8 m x 0.8 m (1.5 $m^2$) / Nanolab
3. Langmuir Trog (Filmwaage) in Einhausung + Elektronik 3.0 m x 0.9 m / CAU Kiel
4. HF Abzug mit Spüle und Neutralisationsanlage im Unterschrank 1.2 m x 0.9 m
5. Abzug anorganische Chemie (Lager im Unterschrank) 1.2 m x 0.9 m
6. Abzug organische Chemie (Abfälle im Unterschrank) 1.2 m x 0.9 m
7. Laminar flow bench 1.1 m x 0.5 m / CAU Kiel
8. Reinstwasser Anlage 0.8 m x 0.8 m
9. Kühl-Gefrier Kombination Labor 0.6 m x 0.6 m
10. Laborbank 3.2 m x 0.9 m
11. Induktionsofen 1.2 m x 0.8 m / CAU Kiel

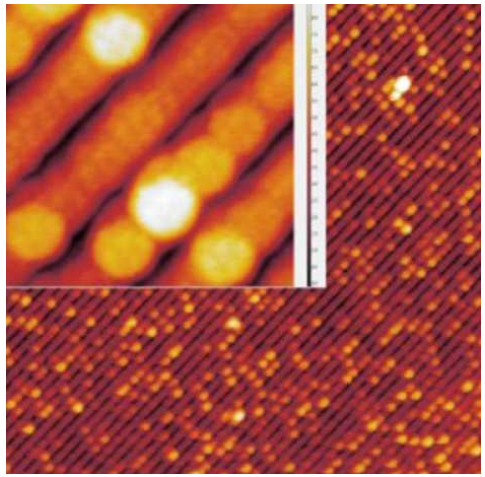
# Microscopy & Structuring

## Nova Nano SEM 450, FEI

- Highest lateral resolution
  1.0 nm @ 15 kV, 1.4 nm @ 1 kV
- Operation at 30 kV - 200 V
  for anti-charging: deceleration mode
- Multi detection mode
- EDX
- Pt marker deposition



## Dimension Icon AFM

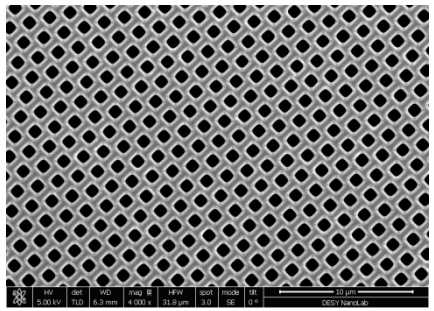
Major operating modes:
- tapping / contact mode
- STM mode
- Force spectroscopy
- Lateral force microscopy (LFM)
- Magnetic force microscopy (MFM)
- KPFM module (Kelvin probe force microscopy)
- Liquid cell
- Electrochemical cell with potentiostat

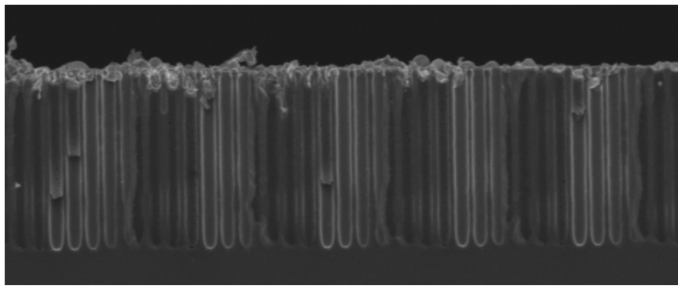
# SEM and EDX application: Filling of porous materials

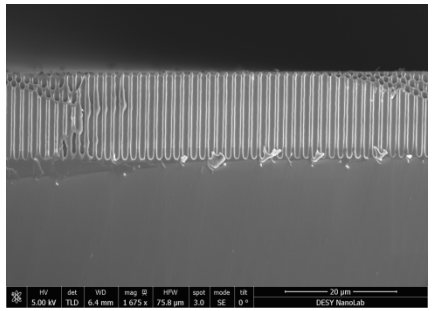
Porous silicon filled with
Semiconducting polymer

**Energy-dispersive spectroscopy**

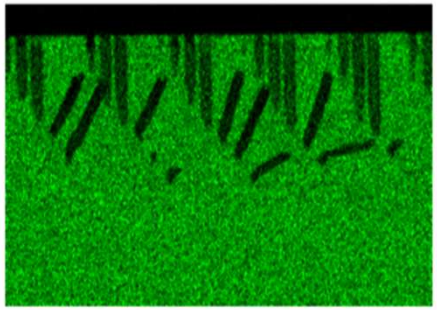
***Surface topography***
***and chemical structure***



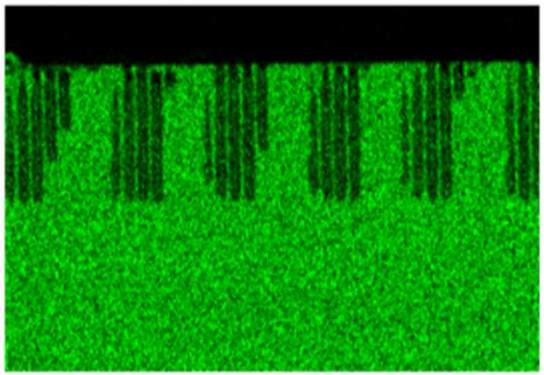




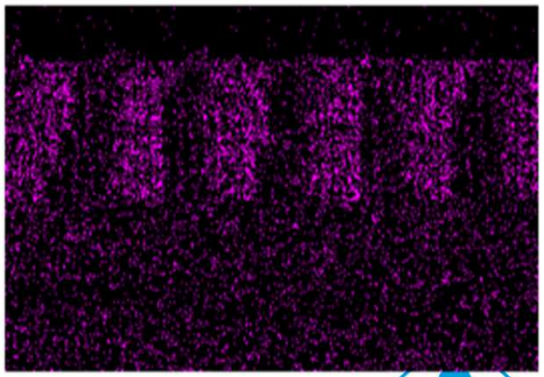
Si Kα1




Si Kα1




N Kα1_2

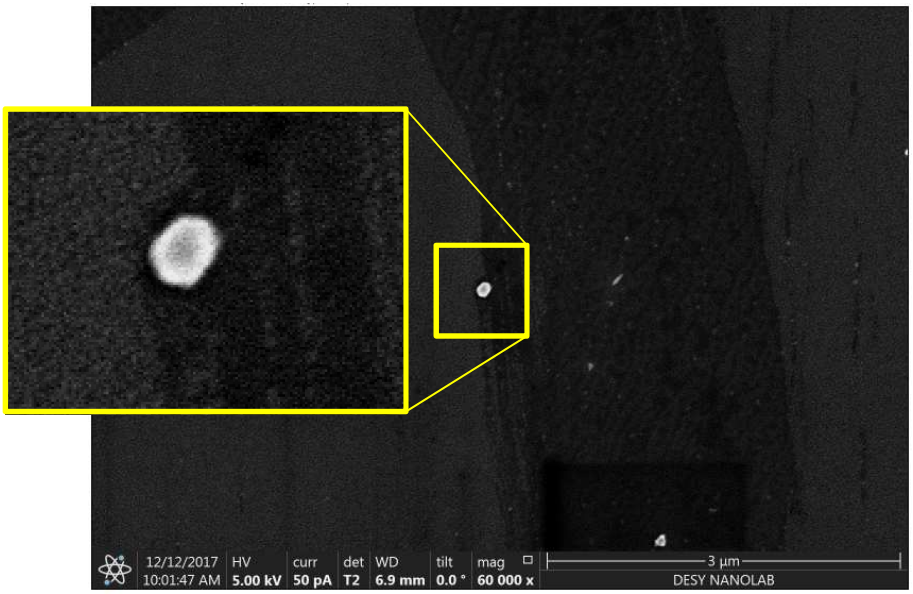



**Guido Dittrich, Bachelor Thesis, University Hamburg and TU Hamburg**

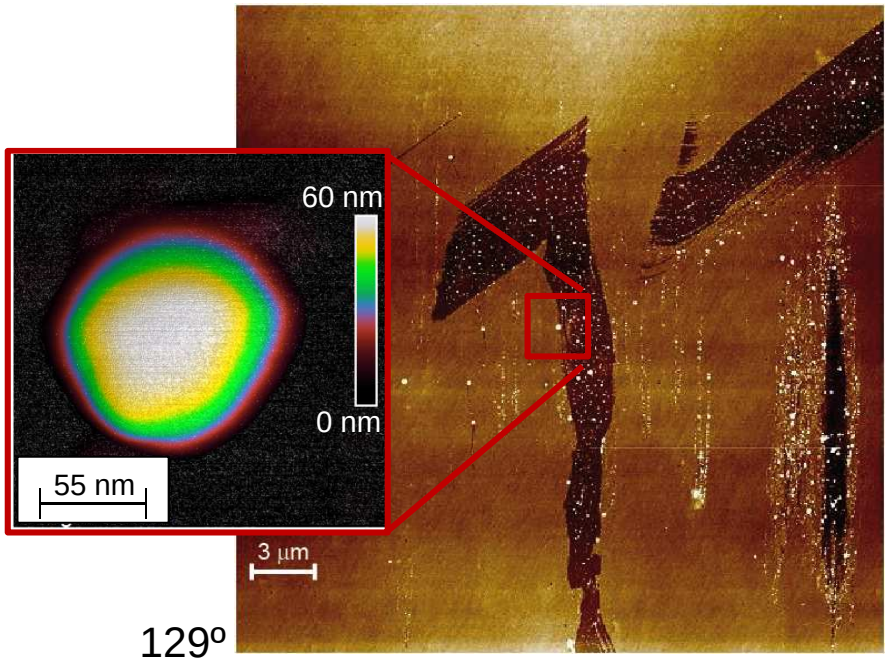
# Microscopy & Structuring

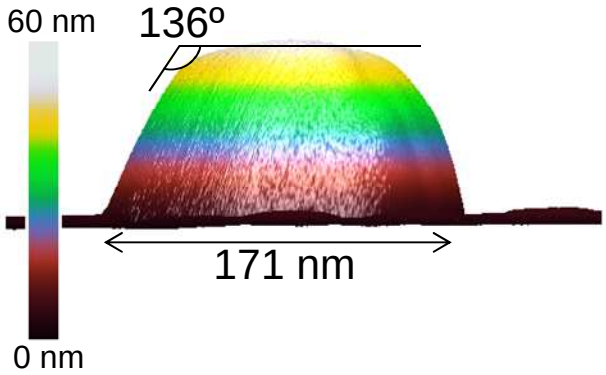
## Nano transfer & positioning of a PtRh catalyst nanoparticle

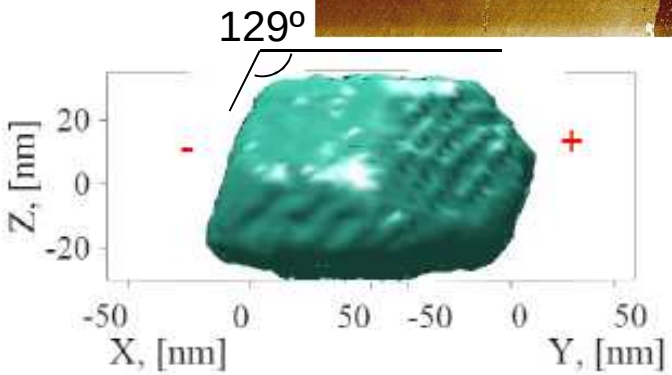
SEM image:




AFM image:



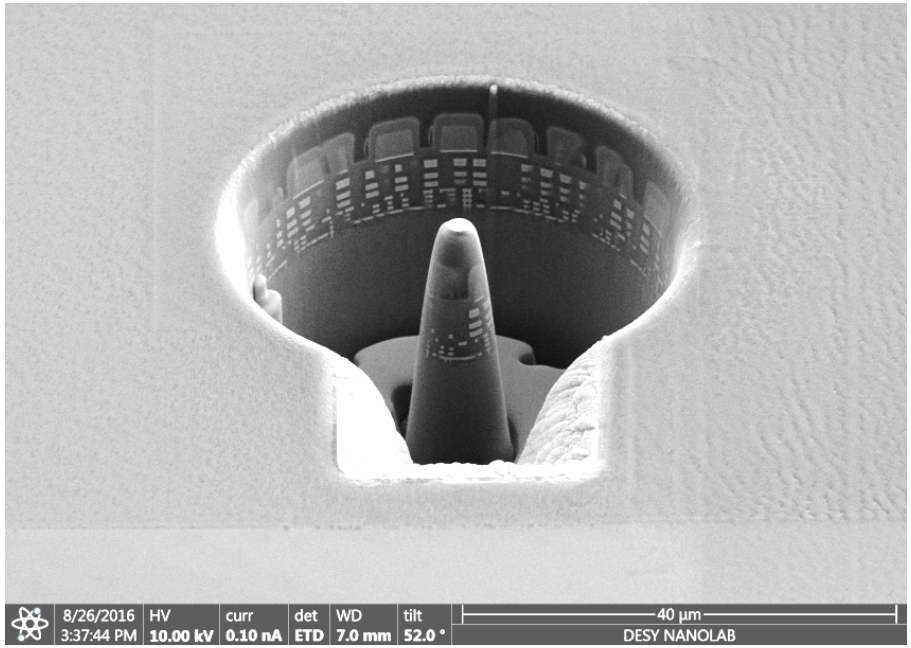




Bragg CDI reconstruction under NAP CO oxidation conditions

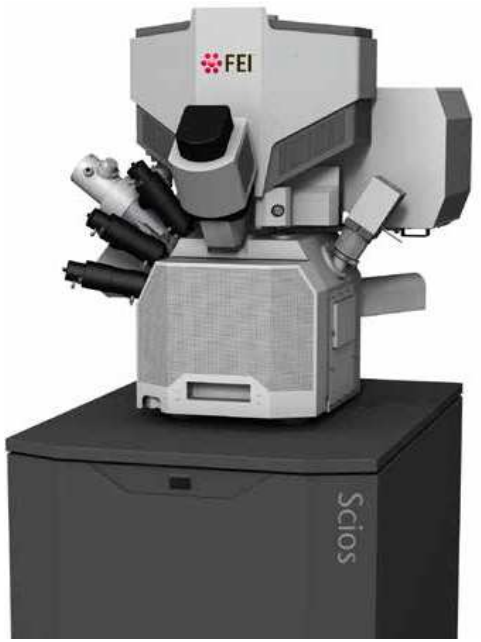
M. Abuín, S. Kulkarni, T. Keller, cooperation with I. Vartaniants group

# FIB - Dual electron and Ga focused ion beam

- cross section sample preparation
- 3D tomographic imaging (IC structure, Ch. Schroer group)
- gas dosing system for marker fabrication and manipulation
- EDX analysis




**(future) E-beam lithography in collaboration with University of Hamburg (CHYN)**




*courtesy of FEI* Deutschland *GmbH*

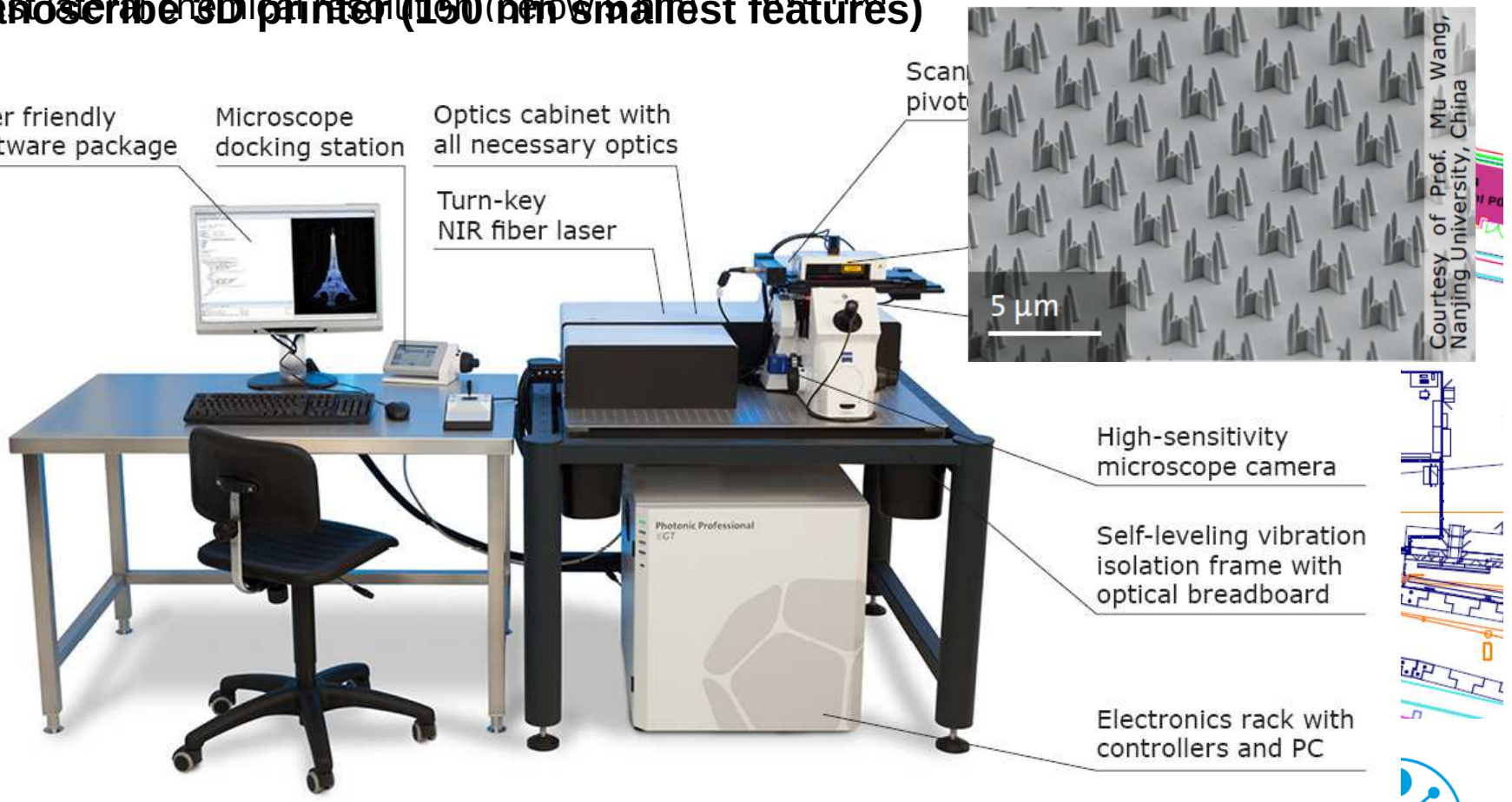
Funded by BMBF / University of Bayreuth
Collaboration with L. Dubrovinsky and P02 diamond anvil HP cell preparation

## Future instruments

Scanning Auger microscope

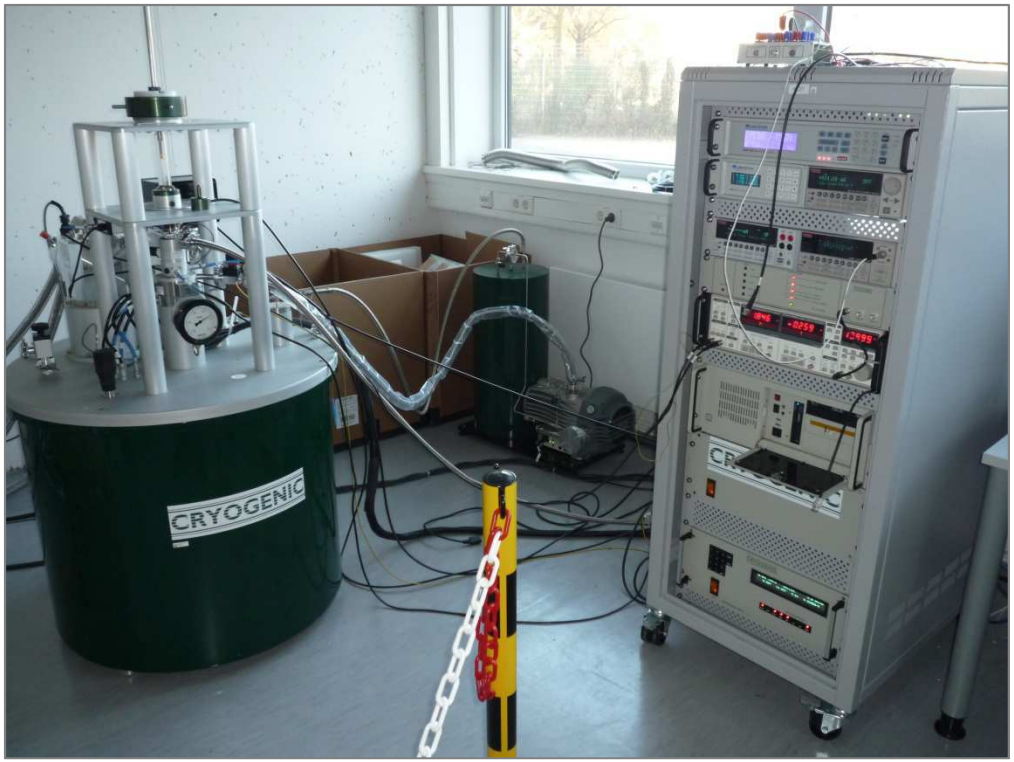
Nanoscribe 3D printer (150 nm smallest features)

MyL hall



# Magnetic Characterization and Transport

CFMS - cryogen free measurement system by Cryogenic Ltd,




**Cryogen free magnet:**

- Field range ±14 T, 20 bit resolution
- 4-quadrant low field option ± 38 mT

**Integrated sample cryostat:**

- Temperature range: 1.6 – 400 K

**Measurement options:**

- vibrating sample magnetometry
- AC susceptibility
- AC and DC resistivity and Hall effect
- AC calorimetry
- thermal transport

Responsible: cornelius.strohm@desy.de

Future instrumentation: Kerr microscope

# Thank You for Your Attention