

**Workshop on  
scale-bridging  
3D-characterization**

July 20<sup>th</sup>, 2021

Universität Siegen



- Lecturers
- Program
- MNaF – Mission, Capabilities, Access
- 3D-Characterization
  - Story of a two-headed Rhino
  - Applications
  - Scale-bridging & Correlative Approach
  - Projection Tomography vs. Serial Sectioning

**Prof. Dr. Benjamin Butz**

Micro- and Nanoanalytics Group LMN &  
Micro- and Nanoanalytics Facility MNaF  
University of Siegen



# Lecturers (alphabetic order)



CT



Dr.-Ing.  
**Benjamin Apeleo Zubiri**



INTRO



Prof. Dr.  
**Benjamin Butz**



FIB



PhD  
**Marco Cantoni**



APT



Prof. Dr.  
**Peter Felfer**



RECON



M.Sc.  
**Xiaohui Huang**



SIMS



Prof. Dr.-Ing.  
**Manuela S. Killian**



TEM



Dr.-Ing.  
**Julian Müller**



EVAL



Dr.-Ing.  
**Pascal Pinter**

# Program

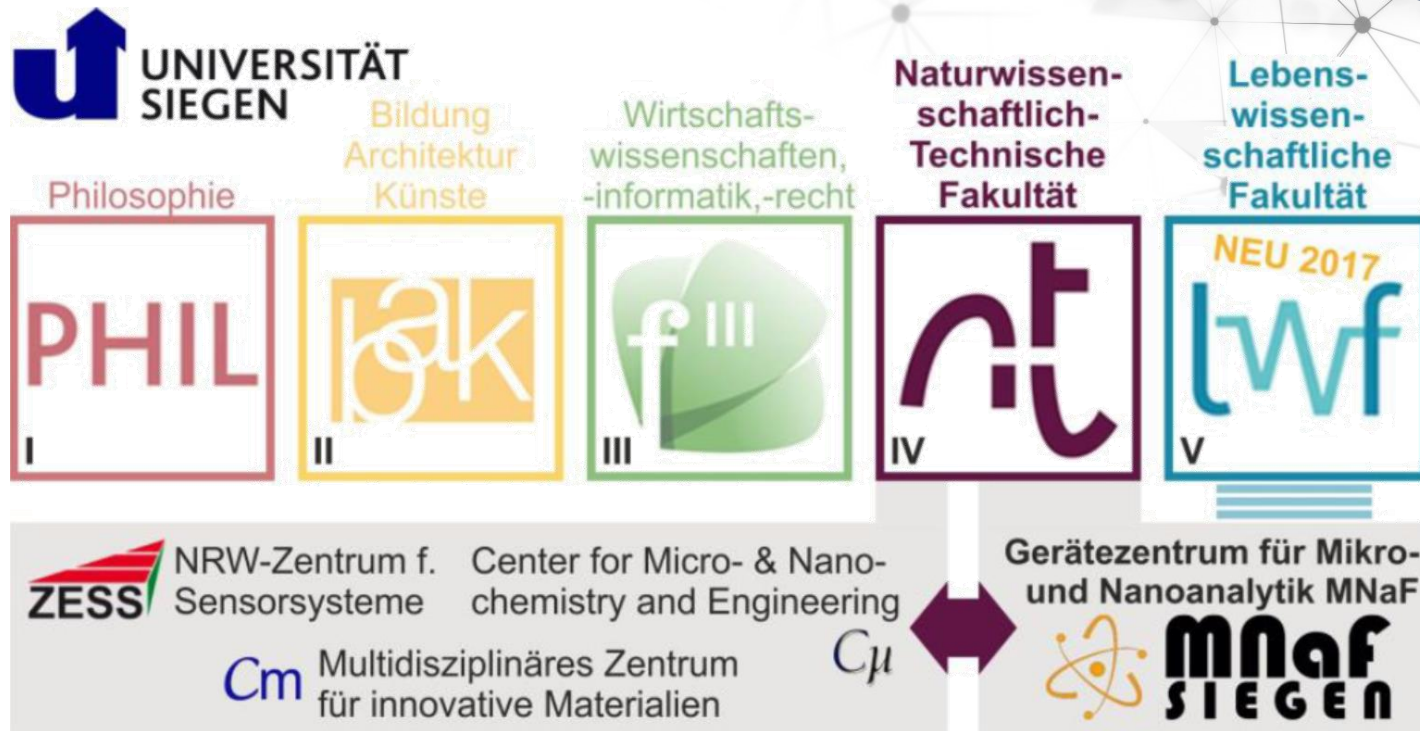
8:30 – 9:00	<b>Introduction</b> to scale-bridging 3D-characterization	Butz
9:00 – 10:00	X-ray microscopy, computed tomography: <b>μCT, nanoCT</b>	Apeleo Zubiri
10:15 – 11:15	(Scanning) <b>TEM tomography</b>	Müller
11:15 – 12:15	<b>3D-reconstruction</b> of projection tomograms	Huang
Lunch break		
13:00 – 14:15	<b>FIB tomography</b>	Cantoni
14:15 – 14:45	<b>3D-SIMS</b>	Killian
15:00 – 16:00	<b>Atom probe tomography</b>	Felfer
16:00 – 17:00	Quantitative <b>evaluation of 3D datasets</b>	Pinter

\*Each lecture will include a Q&A session

**afterwards: 10 minutes [online survey](#) via EvaSys**

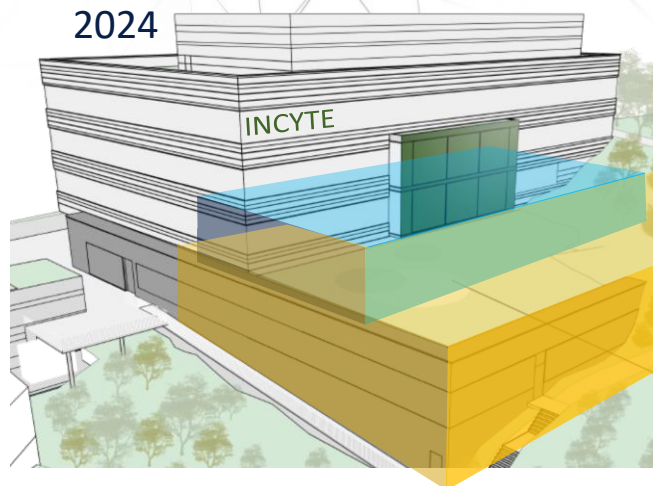
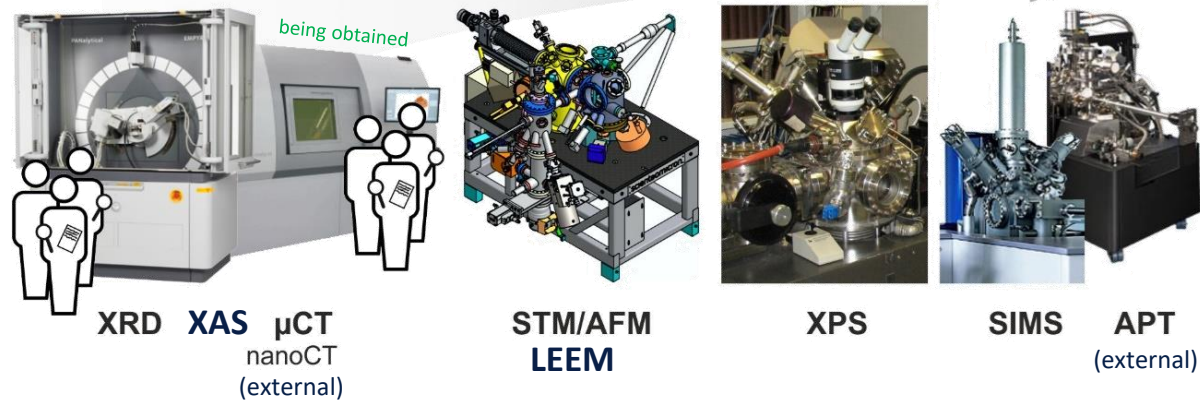
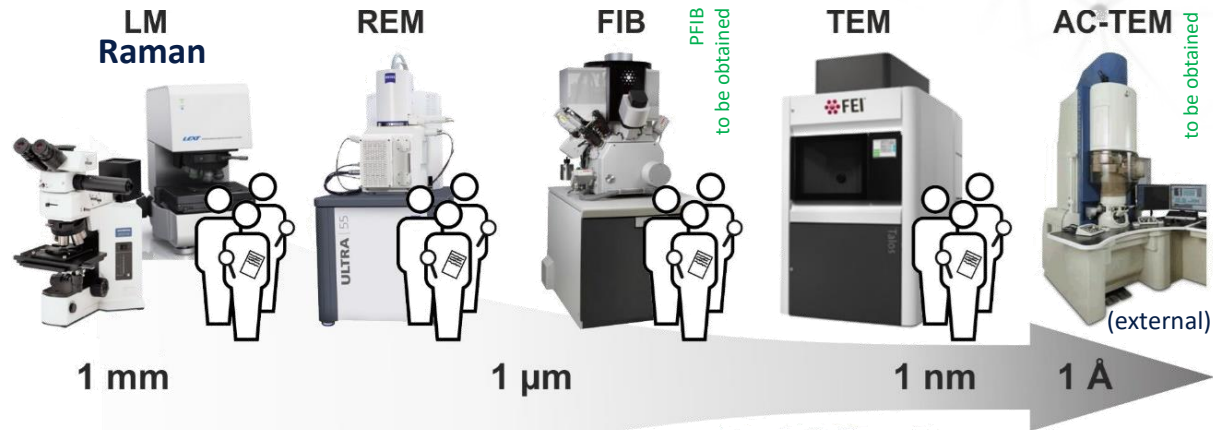
# MNaF – DFG-funded Core Facility

**DFG** Deutsche Forschungsgemeinschaft  
„Gerätezentren – Core Facilities“



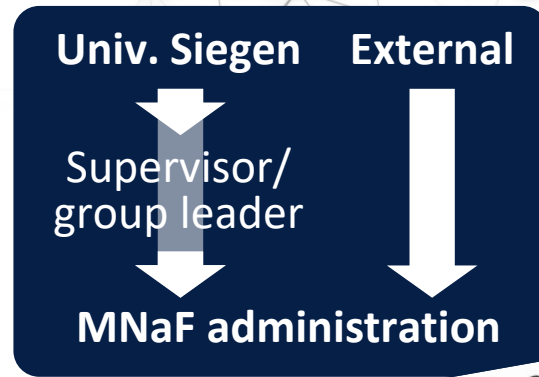
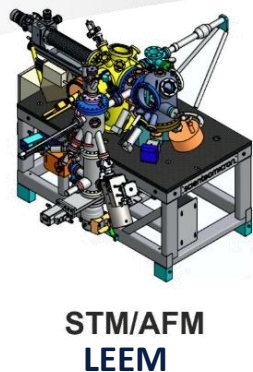
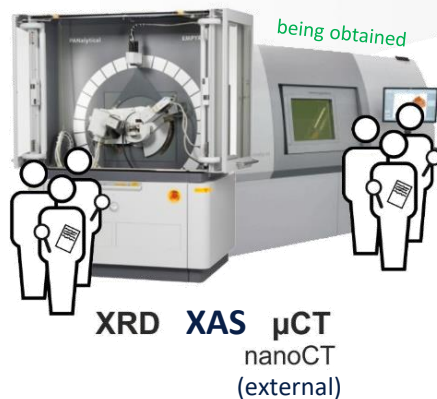
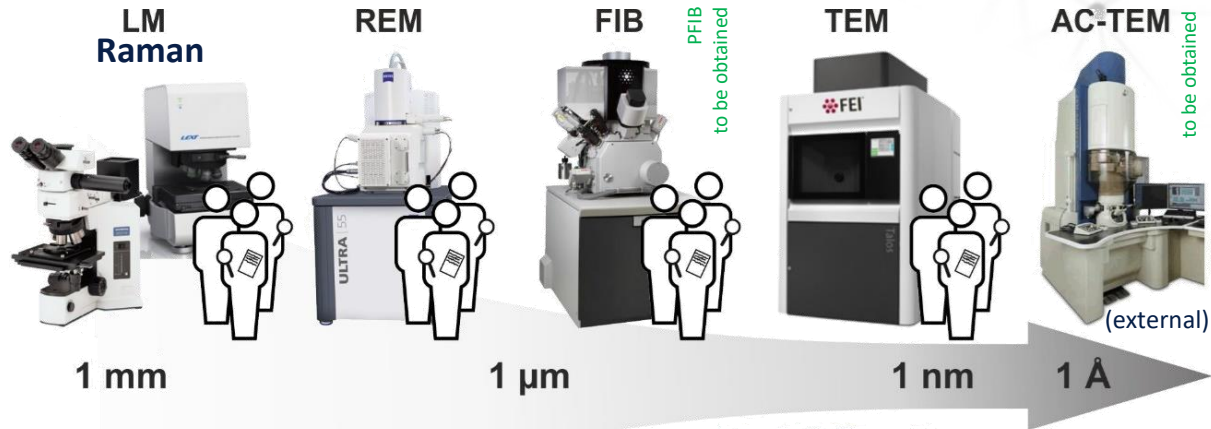
**Scientific board (10 PIs) >100 Users >200 Publications (past 5 years)**

# MNaF – Capabilities & Access



- 7 EM-labs
- 300 m<sup>2</sup> compl. analytics
- 300 m<sup>2</sup> sample prep
- 600 m<sup>2</sup> ISO4 cleanroom
- Group labs & offices (5.500 m<sup>2</sup> funct. space)

# MNaF – Capabilities & Access



# MNaF – User Support



TEM '18 / '19



Int'l GIAN Workshop '18 / Delhi



REM/FIB & SIMS '20

## Annual Summer Schools



*SEM, FIB & ion microscopy*  
*TEM imaging & diffraction*  
*X-ray techniques (2021)*

📅 4x 1,5h    🧪 4x 4h    👥 3(-5) per group

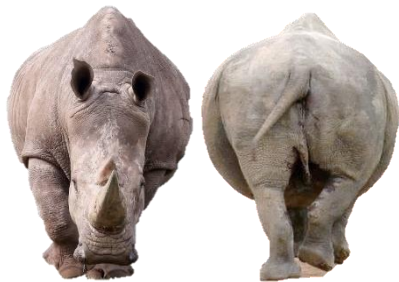


# Why 3D-analytics?

Two-headed rhino as new species?



Most probably not!



[serengeti-park.de](http://serengeti-park.de), [naturdetektive.de](http://naturdetektive.de)





# Applications

## Quality assurance

Phase distribution (composites)

Voids, inclusions

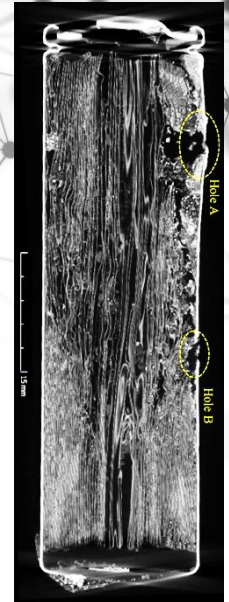
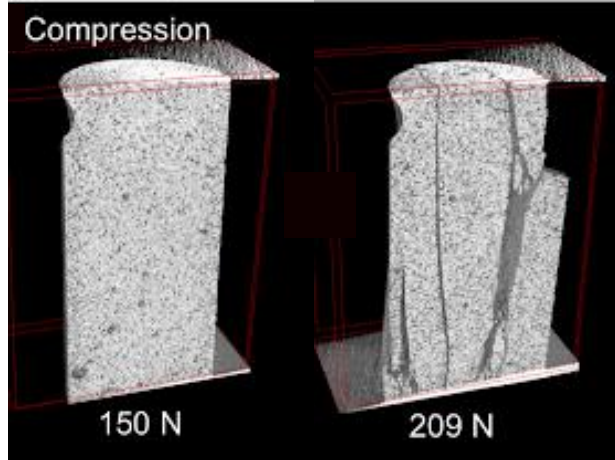


## Metrology

Shape assurance

## Failure analysis

Cracks, breakdown, runaway



Static measurements



*in situ / in operando* analyses

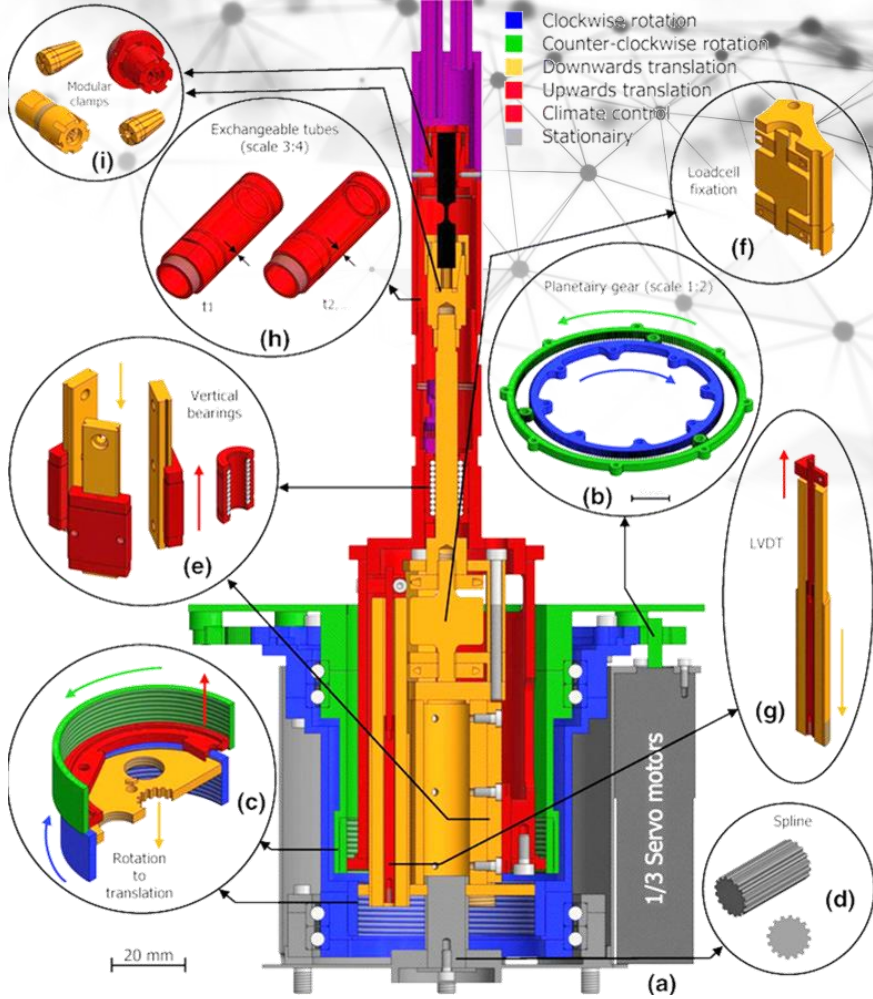
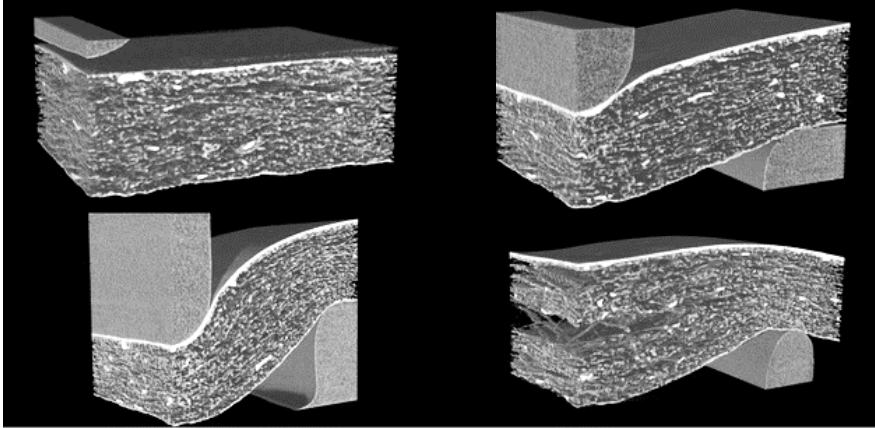
mech. load, biasing, heating, environment, ...

Kong *et al*, Fire Tech., 56 (2020) pp. 2565

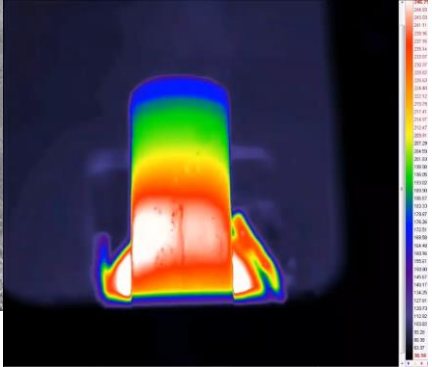
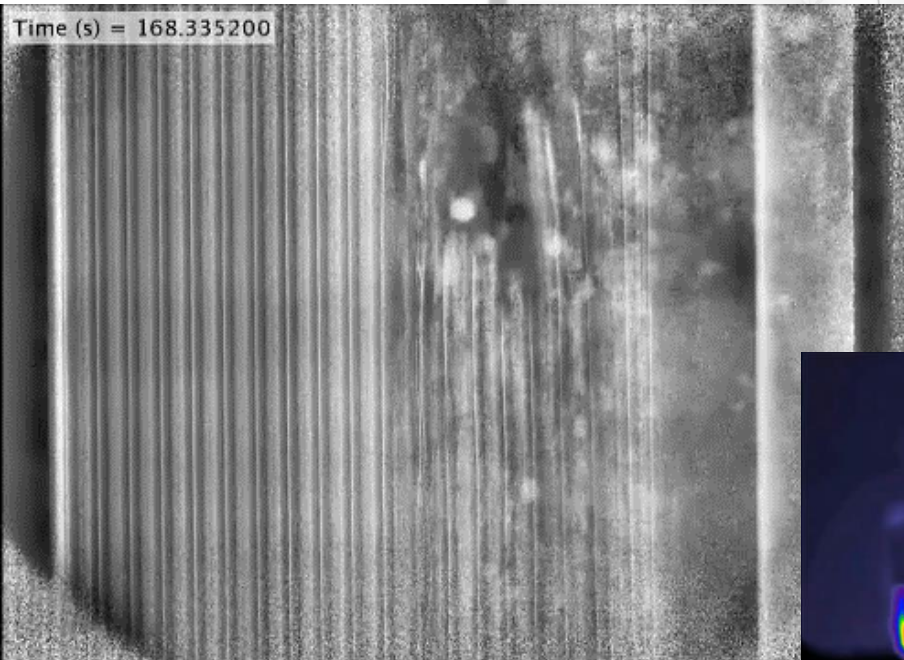
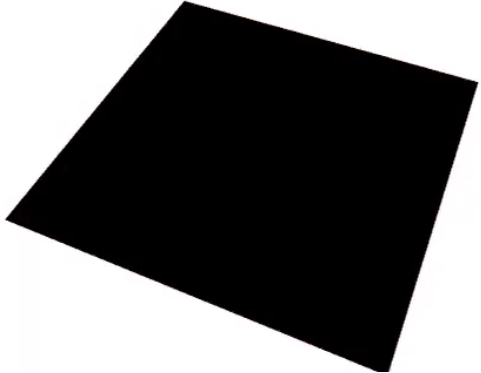
Gallinetti *et al*, Front. Bioeng. Biotechnol. (2016) DOI: 10.3389/conf.FBIOE.2016.01.00704

# Applications: Mechanical Failure

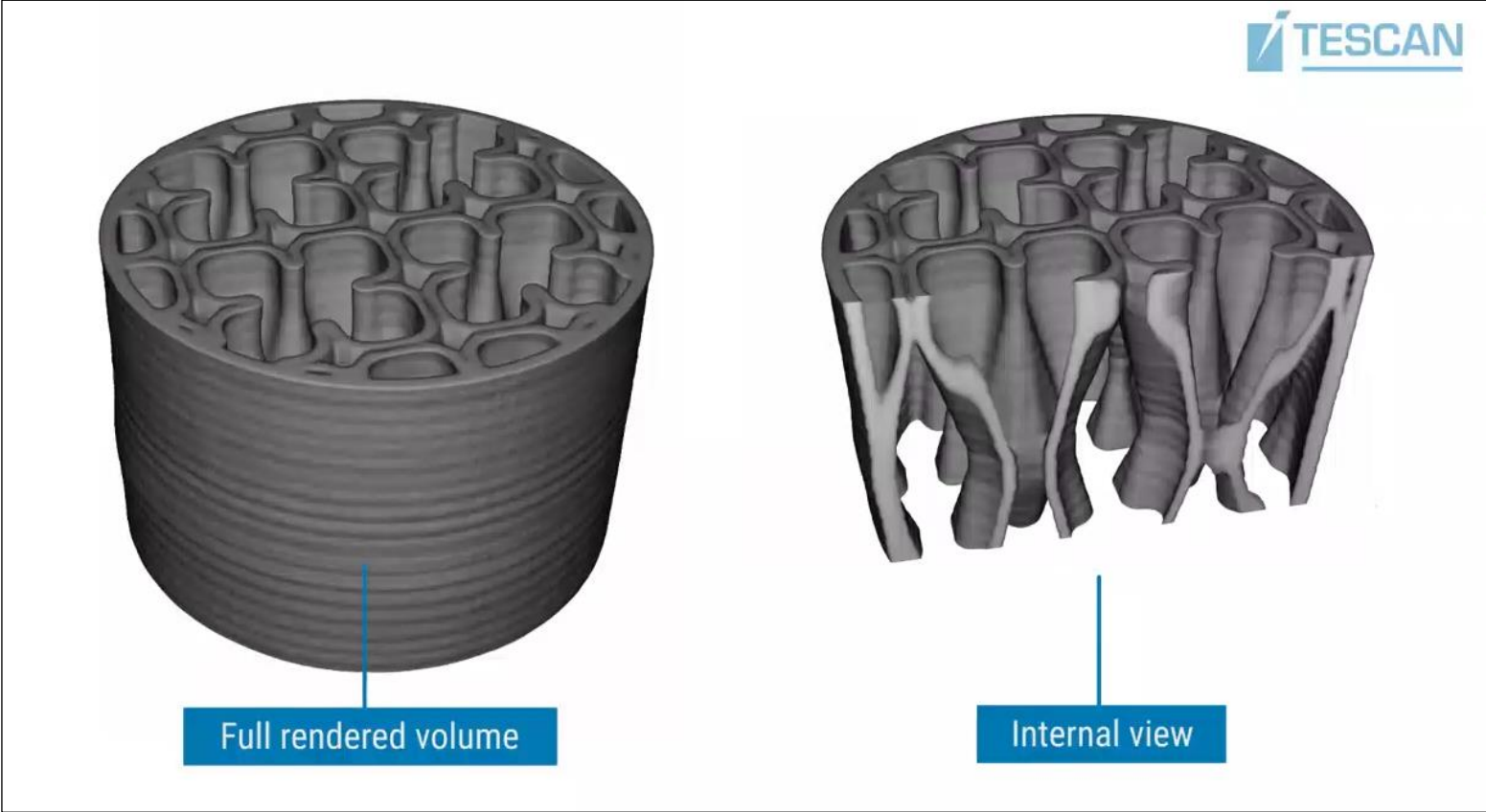
## Delamination & failure of composite (cardboard)



# Applications: AA Battery Runaway



# Applications: Part Optimization



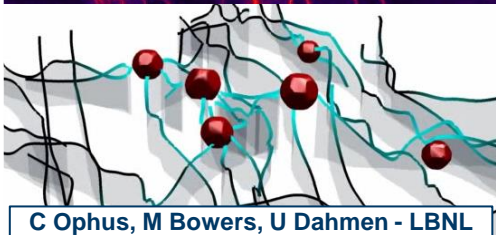
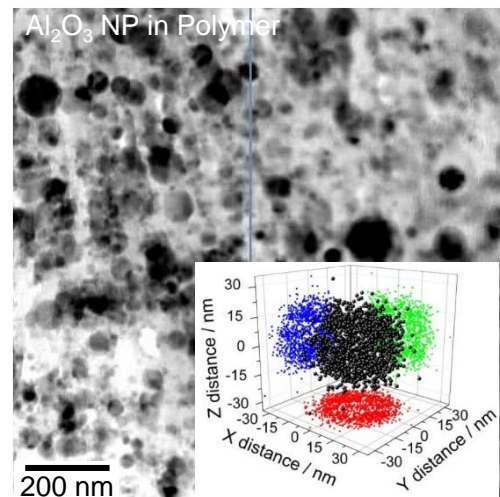
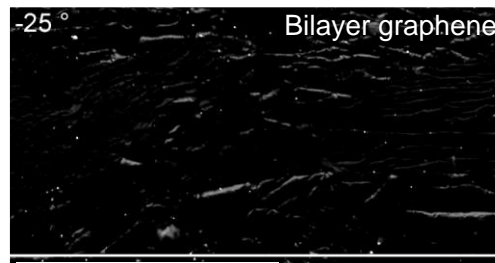
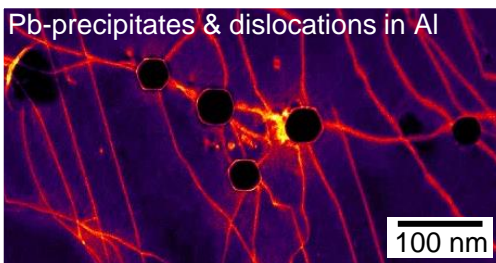
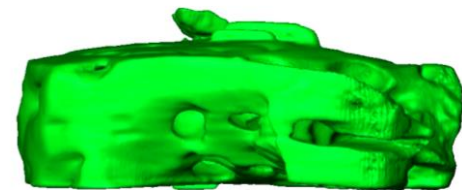
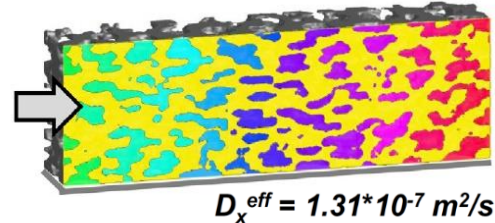
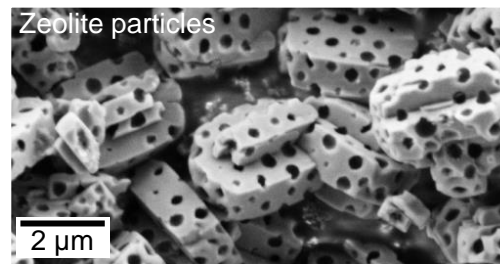
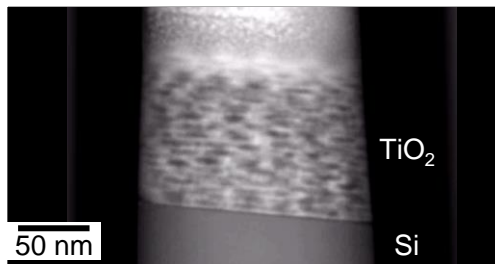
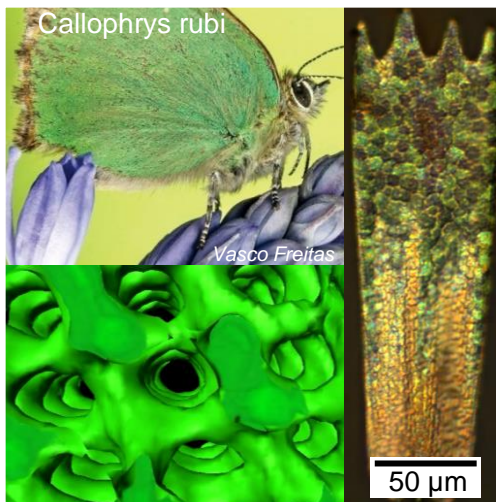
# Applications

## Materials research

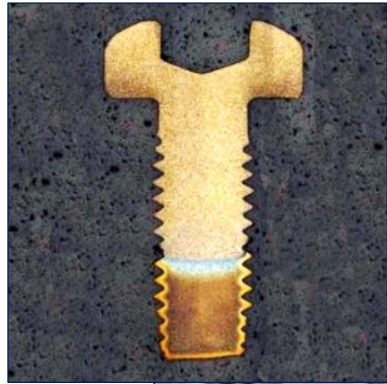
Morphology/  
structure  
formation

Phase  
distribution  
Defects

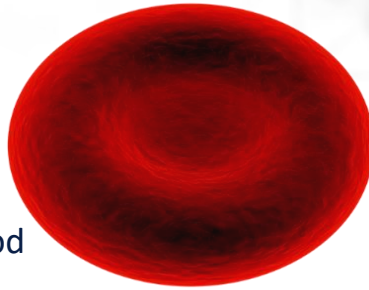
...



# Scales

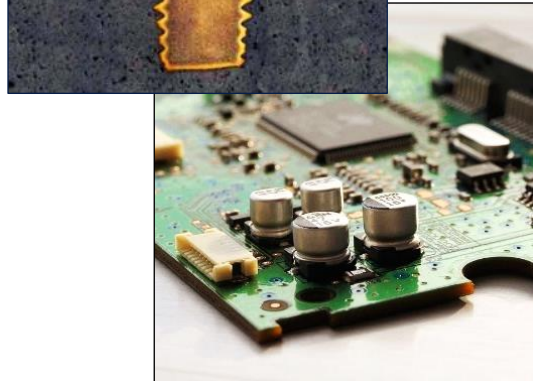
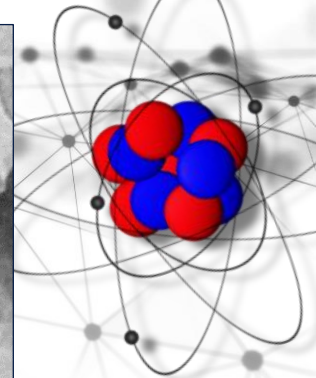
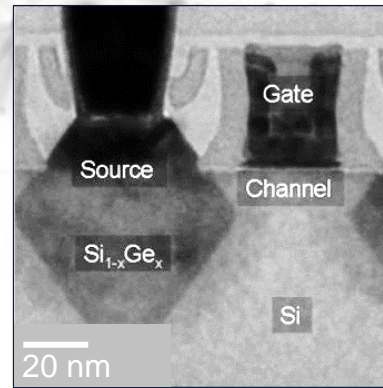


Screw



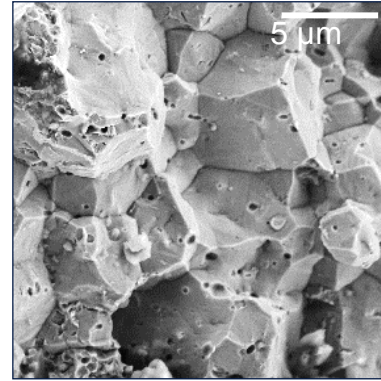
Red blood cell

pFET

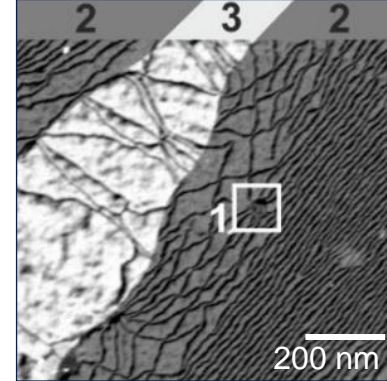


Circuit

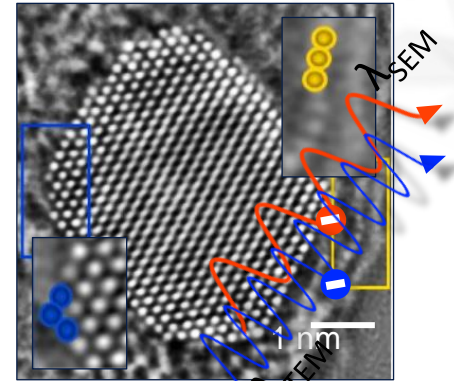
Fracture surface



Crystal defects



Pt-NP



IR

Visible light

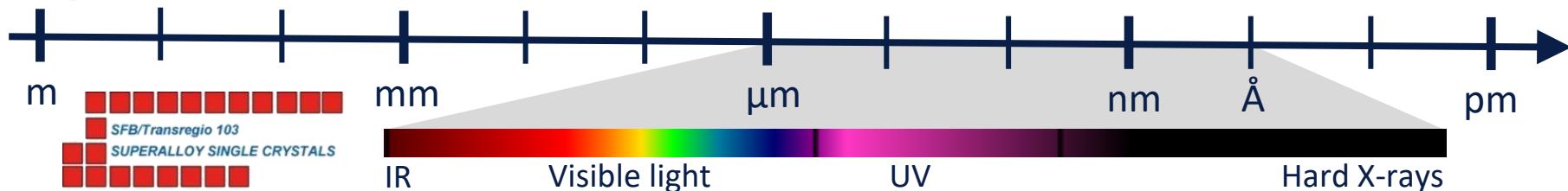
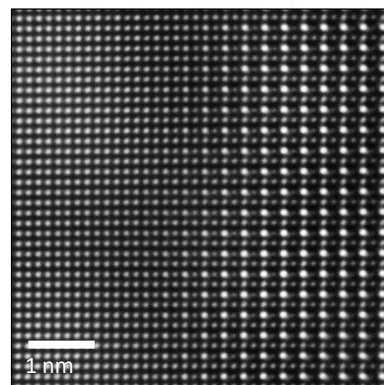
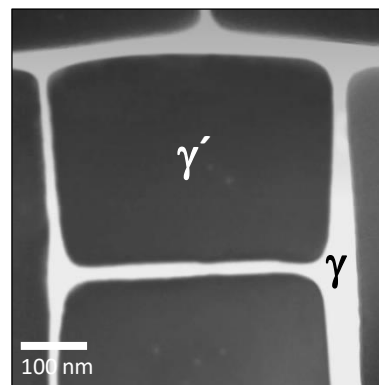
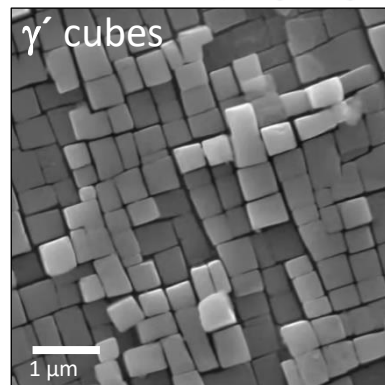
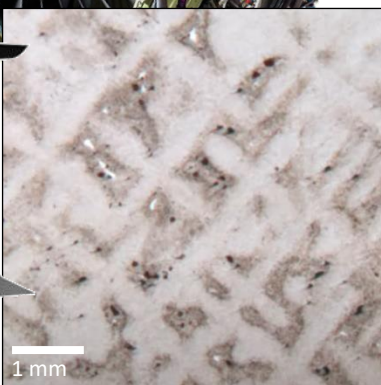
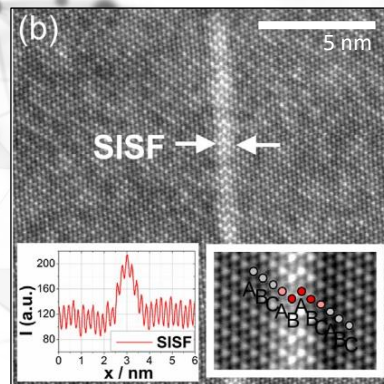
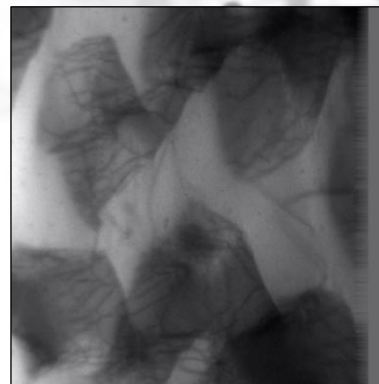
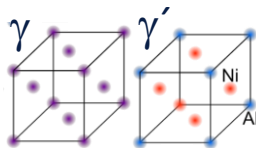
UV

Hard X-rays

# Scales



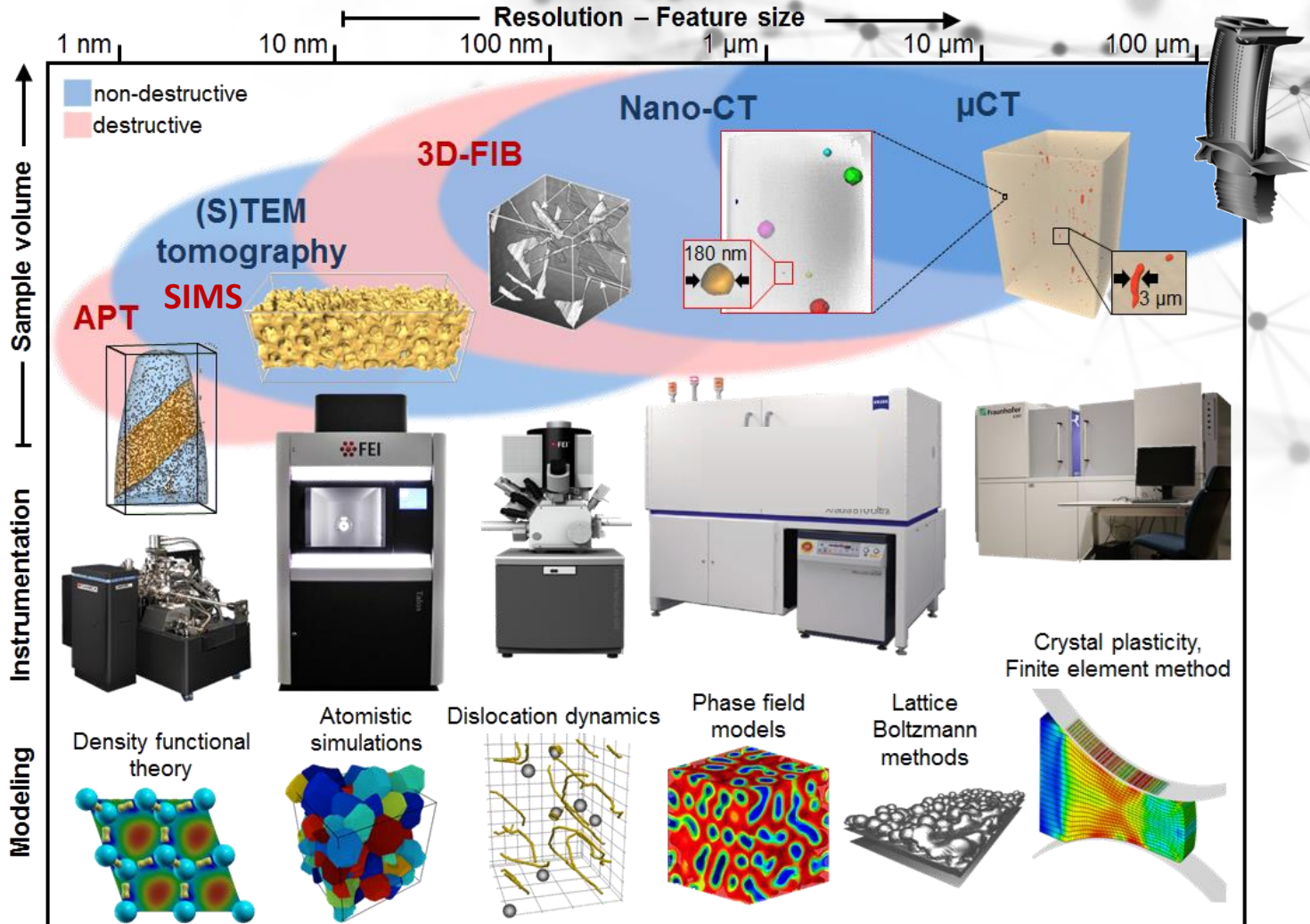
after creep deformation



SFB/Transregio 103  
 SUPERALLOY SINGLE CRYSTALS

# Scale-bridging & Correlative Approach

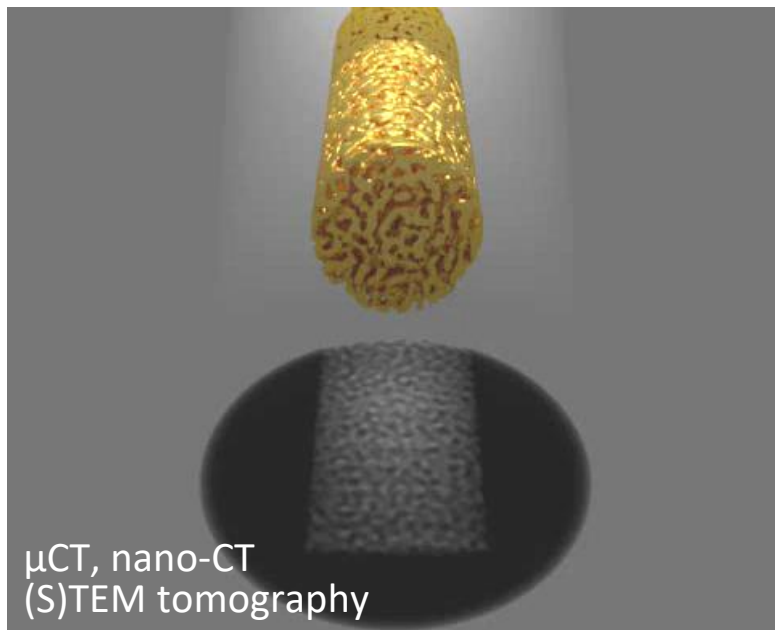
3D-techniques for all length scales!



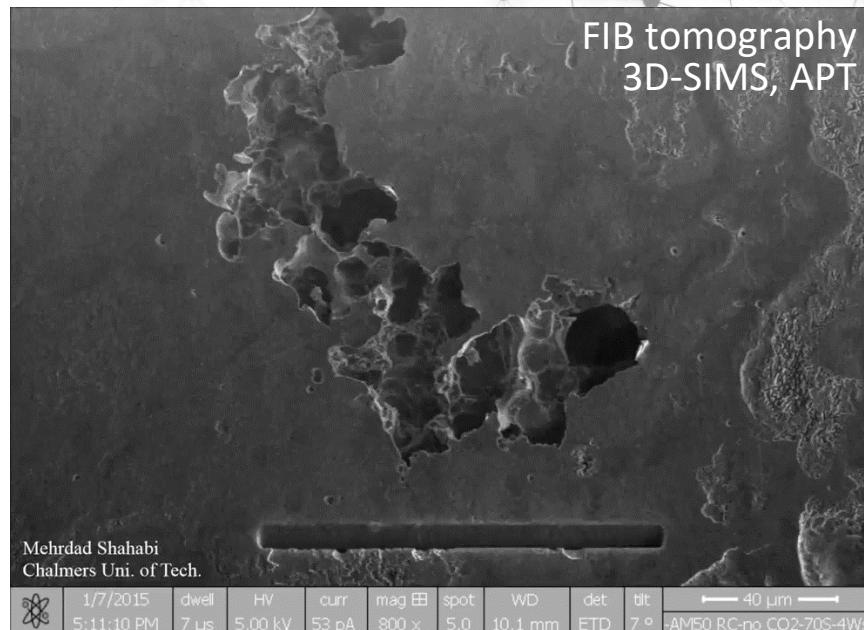


# Projection Tomography vs. Serial Sectioning

## Projection tomography



## Serial sectioning



Both techniques necessitate suited reconstruction algorithms!

# Program

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**afterwards: 10 minutes short online survey via EvaSys**