Opportunities of transnational access for industries in ESTEEM3

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Industrial contact in ESTEEM3

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Overview

- Background
- Benefits for industry
- Application process
- Conditions for industry
- Examples from research in JRA materials sectors
- Final comments

ESTEEM3 Transnational Access

- Projective objective
  - Provide Transnational Access (TA) for the academic and industrial research community in the physical sciences to some of the most powerful characterisation techniques available at the nanoscale.

- Application process described on web-site https://www.esteem3.eu/
  - Send open or lab proposals.
  - Companies are invited to contact industry liason officers or consortium members.
  - Applications evaluated by Transnational Access Proposal Evaluation Committee (TAPEC).

TEM in industry

- TEM is expensive - investment, operating costs, competence building.
- State-of-the art is under continuous development.
- Investment in TEM infrastructure challenging for larger companies and likely impossible for SMEs.
- Outstanding facilities are available in Universities and research Institutes.

Benefits for companies

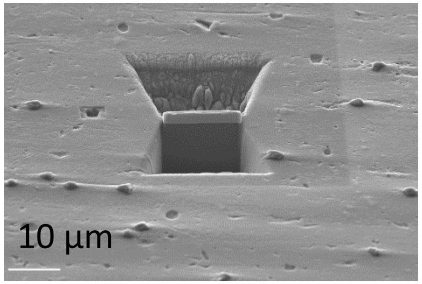
- Transnational Access in ESTEEM3 is a mechanism to provide fully funded access to TEM facilities in the consortium.
- This includes sample preparation, TEM analysis and data processing.
- TA presents an excellent opportunity to;
  - Carry out small scale studies.
  - Building platform for larger-scale study.
  - Learn about the potential of TEM in your area of interest.
  - Strengthen existing TEM competence.
  - Establish contact with expert TEM research environments.

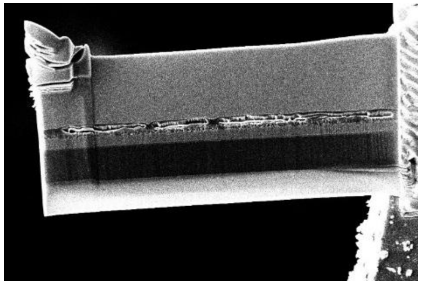
Confidentiality and IP

- For larger companies, the outcome of the work must be disseminated.
- SMEs can retain full IP.
- Non Discolure Agreements can be established for discussion and protection of existing IP.
  - Project descriptions are only seen by the TAPEC committee, the institution performing the work and the company.
  - TA is administered by Euronovia.

Scope of applications

- Sample preparation
  - E.g Focussed Ion Beam (FIB)
- TEM analysis
- Data processing





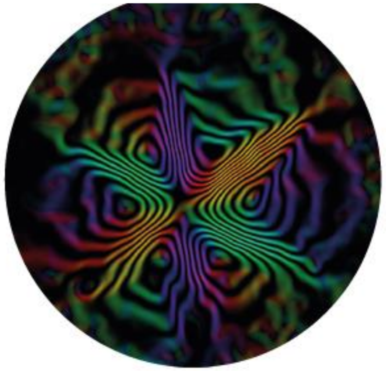
- Unit of 1 day and <u>up to</u> 20 days in total.
- Cannot be all TEM
  - e.g. 6 prep + 6 TEM + 8 data = 20
- Accommodation can also be supported.

Examples of topic areas

- Area of ongoing industrial TA projects include
  - Nanoscale semiconductor materials
  - Light metal alloys
  - Powder metallurgy
  - 2-D materials

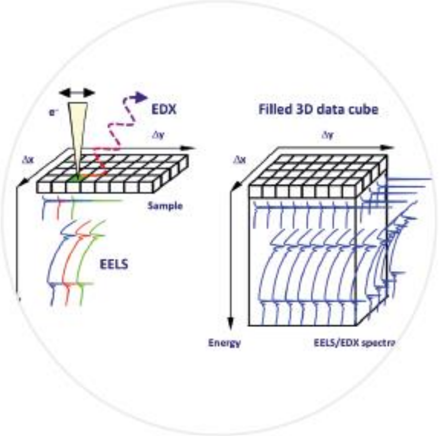
ESTEEM3 focus areas

- JRA 1
  - Imaging, Diffraction and Metrology, Spectroscopy, In-situ TEM.
- JRA 2
  - See following slides.
- JRA 3
  - Data acquisition and analysis in TEM – see next slide.



Magnetic induction of a FeCo nanostar observed by off-axis electron holography

Credits picture JRA1 - L.-M. Lacroix and C. Gatel (CNRS-CEMES)



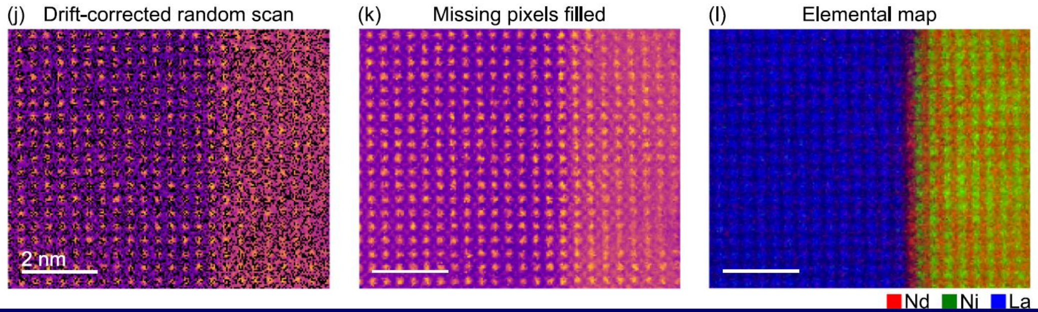
Data processing in EELS and EDS filling up a multidimensional data cube

Credits picture JRA3 - Peter van Aken (MPG-StEM)

Data acquisition and analysis

- Instrument control, data acquisition, data processing and machine learning with reduced human intervention using automated and smart workflows.
- Open software for the design and interpretation of experiments, including electron generation, propagation, scattering and detection in standard and specialized imaging modes will be investigated.
- All advances will be directly transferred to TA users.
- Data analysis platforms
  - Hyperspy (https://hyperspy.org/) Python library which provides tools to facilitate the interactive data analysis of multi-dimensional datasets.
  - Pyxem (HyperSpy-based): multidimensional diffraction microscopy
  - LumiSpy (HyperSpy-based): analysis of luminescence data
  - LiberTEM: Open-source platform for efficient, parallel and distributed data processing

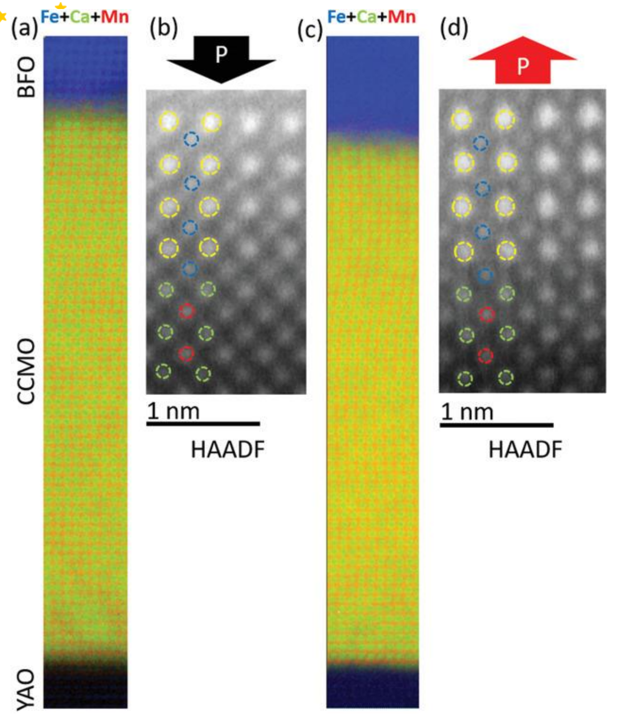
Spatial and spectral dynamics in STEM hyperspectral imaging using random scan patterns, Zobelli et. Al. Ultramicroscopy, DOI: 10.1016/j.ultramic.2019.112912



JRA 2 - Eligible areas

- Proposals should describe relation to the main sectors addressed by JRA 2:
  - Materials for ICT.
  - Materials for Energy.
  - Materials for Health.
  - Materials for Transport.

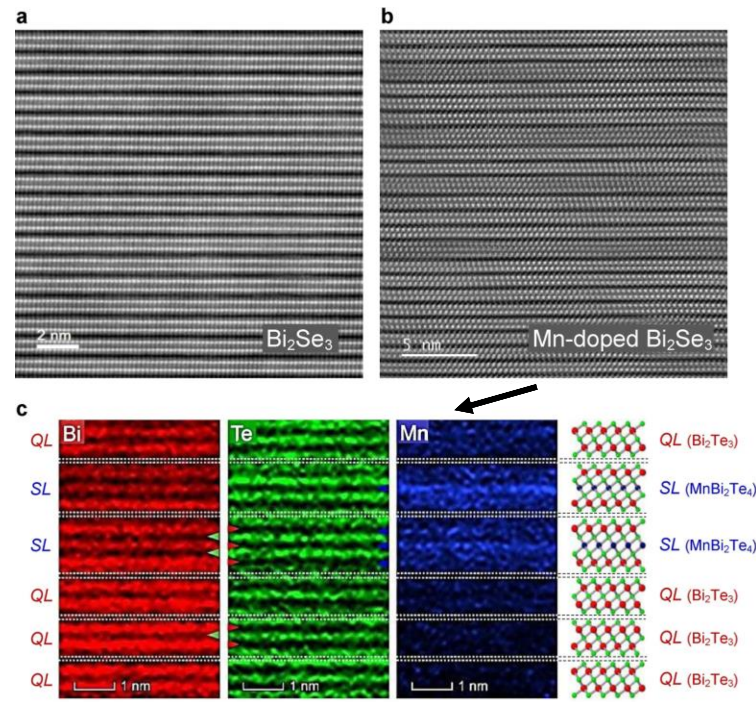
ICT



In-Depth Atomic Mapping of Polarization Switching in a Ferroelectric Field-Effect Transistor

- Nanoscale changes at interfaces observed directly.
- HAADF and EELS chemical maps.

Li et al, Adv. Mater. Interfaces 2020, 7, 2000601

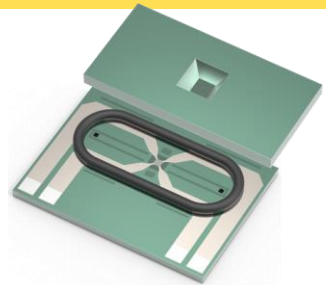


Large magnetic gap at the Dirac point in $Bi_2Te_3/MnBi_2Te_4$ heterostructures

- HR-STEM cross sections and EDS maps show atomic structures.

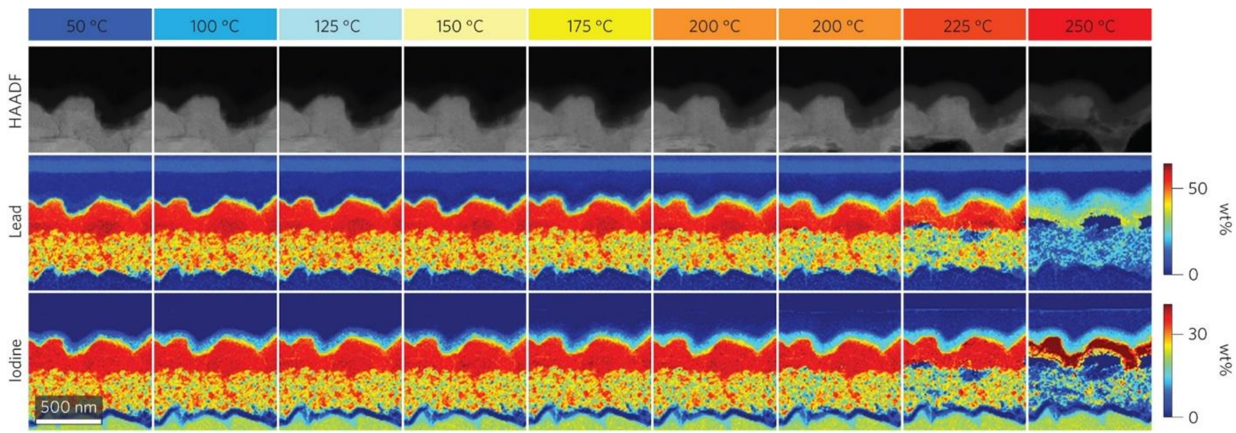
Rienks, et al, Nature 2019, 576, 423

Energy - in-situ TEM studies



Courtesy DENS solutions

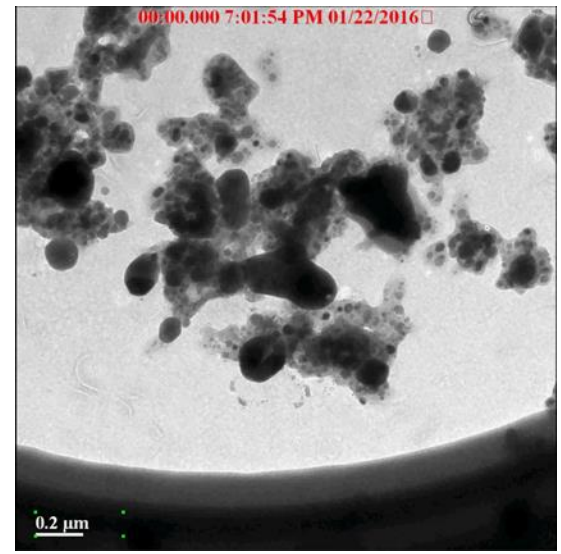
Temperature: 730°C
Pressure: 1 Bar
Gas: $He+H_2+O_2$ (flow)



In situ observation of heat-induced degradation of perovskite solar cells

- Diffusion of I and Pb after increasing temperature steps.
- Diffusion of I into the HTM from the $MAPbI_3$ is clearly visible at low temperature.
- Pb migration is triggered at higher temperature (~175 C).

Divitini et al, Nature Energy, 2016, 1, 15012



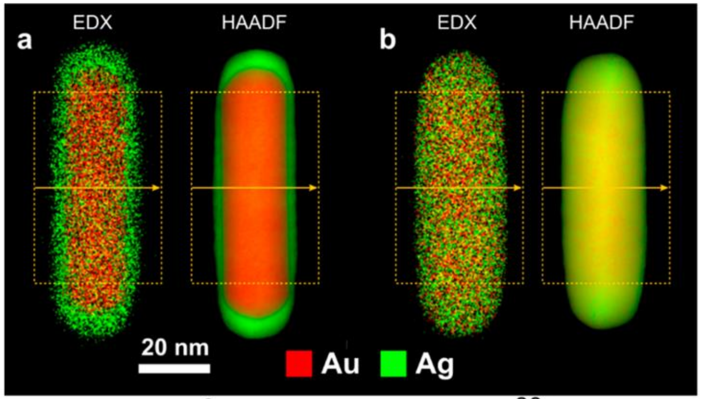
In-situ reduction of NiO catalyst

Researchers:

Dr. R. Fara, Dr. M. Willinger. Fritz Haber Institute Berlin

Dr. Qiang Xu. DENSsolutions

Health



3D investigation of AgAu nanoparticles using heating tomography

- Structure reconstructed from STEM images and EDX analysis.
- Metalic NPs have wide range of biomedical applications
- Alloying in AgAu nanoparticles
- Importance for sensing, (optical) hyperthermic cancer treatment

Skoriov et al, ACS Nano 2019, 13, 13421−13429

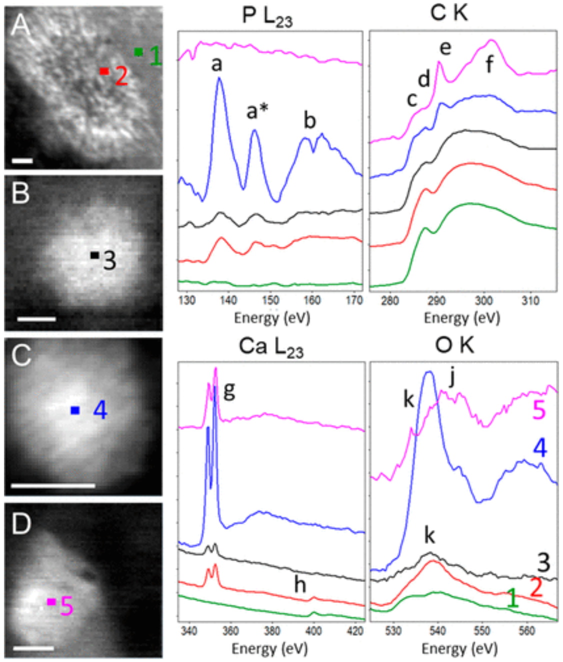


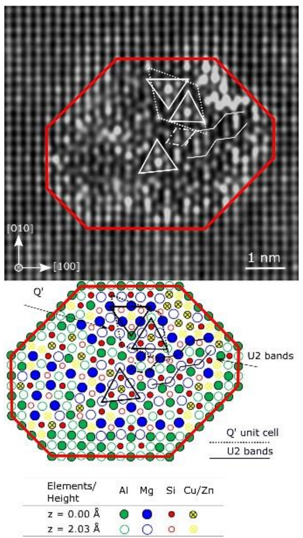
Figure 7. Edge features for different calcifications: red curves are associated with small MPs enclosed in a vesicle for the position indicated by the red square in the HAADF image A; black and blue curves correspond to large MPs made of calcium phosphate (respectively black and blue squares in B and C); purple curves correspond to a large MPs made of pure calcium carbonate (purple square in D). For comparison, the green curves correspond to organic material and resin (green square in A). Scale bar = 50 nm.

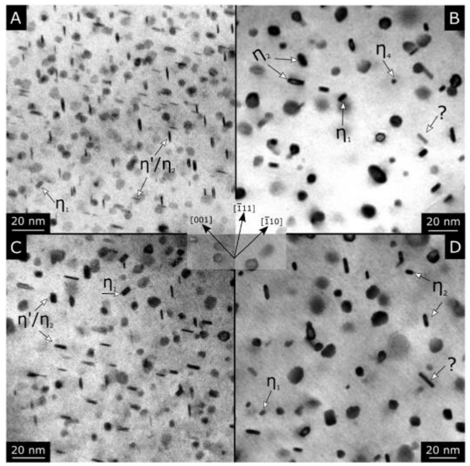
Nanoscale study of kidney calcifications formation

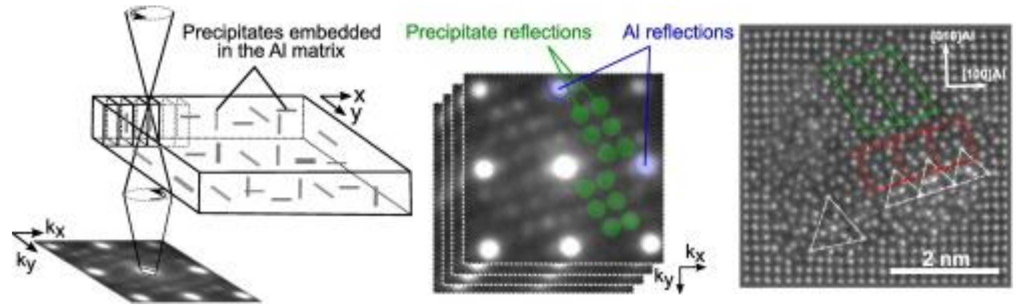
- Core loss EELS analysis of mineral particles.

Gay et al, ACS Nano 2020, 14, 1823−1836

Transport







Precipitation in an extruded AA7003 aluminium alloy:

- Observations of 6xxx-type(Mg-Si) hardening phases in 7xxx (Mg-Zn) alloy.

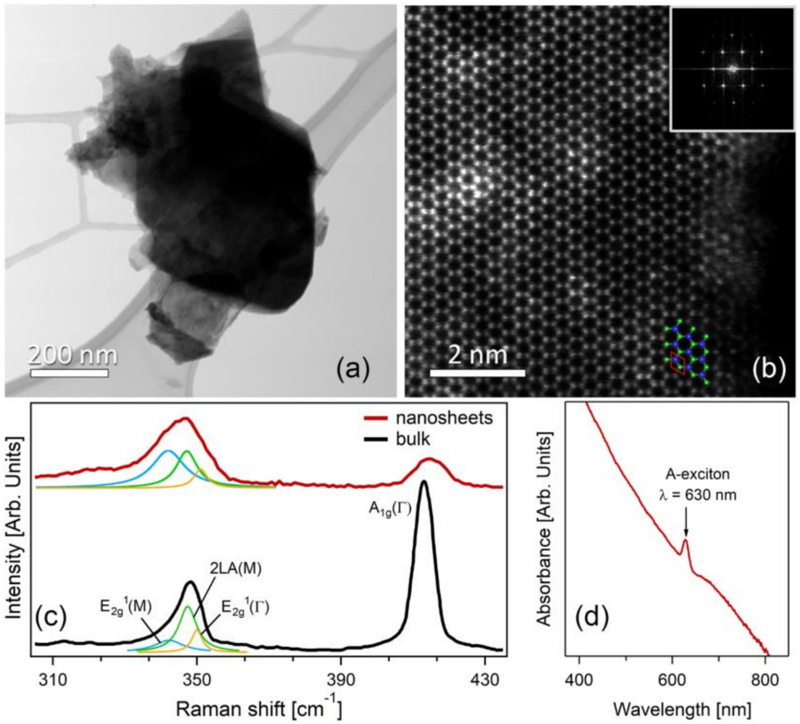
The evolution of precipitate crystal structures in an Al-Mg-Si(-Cu) alloy studied by a combined HAADF-STEM and SPED approach

- Mapping crystallography.

Lervik et al, Materials and Design 2020, 186, 108204

Sunde et al, Materials Characterisation, 2018, 142, 458-469

Example of completed industry TA



- Liquid phase defoliation using a non-toxic and biodegradable solvent.
- TEM study complements other techniques.
- WS_2, MoS_2 and graphene studied.
- Figure shows;
  - TEM image of overlapping $W2_S$ flakes
  - Atomic-scale aberration corrected STEM imaging (60 kV) of single layer flake (inset shows W and S positions, blue and green respectively).

Sustainable liquid-phase exfoliation of layered materials with non-toxic Polarclean solvent

Paolucci et. Al. Accepted for publication in ACS Sustainable Chemistry & Engineering
http://dx.doi.org/10.1021/acssuschemeng.0c04191

Other ESTEEM 3 opportunities

- ESTEEM3 also arranges training courses and workshops:

- TEM-UCA workshop on transmission electron microscopy of nanomaterials (Cadiz), 2021
- 6th Stanisław Gorczyca European School on electron microscopy and tomography (Krakow), 2021
- QEM: Review and New Advanced TEM techniques (Toulouse), 2021
- European workshop on quantitative STEM imaging (Ljubljana), 2022
- Sample preparation:

- Workshop on advanced TEM specimen preparation (Stuttgart), 2021

Summary

- ESTEEM3 can provide Industrial TA access to leading European state-of-the-art electron microscopy research infrastructures.
- Free under the conditions defined in the application procedure.
- Potential industry applicants for TA are encouraged to make contact for further discussion.
  - Please find - https://www.esteem3.eu/lw_resource/datapool/systemfiles/cbox/551/live/lw_datei/comic-esteem3-en.pdf

Thank You For Your Attention