In-situ STEM for energy and catalysis nanomaterials

Jordi Arbiol

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CSIC & BIST

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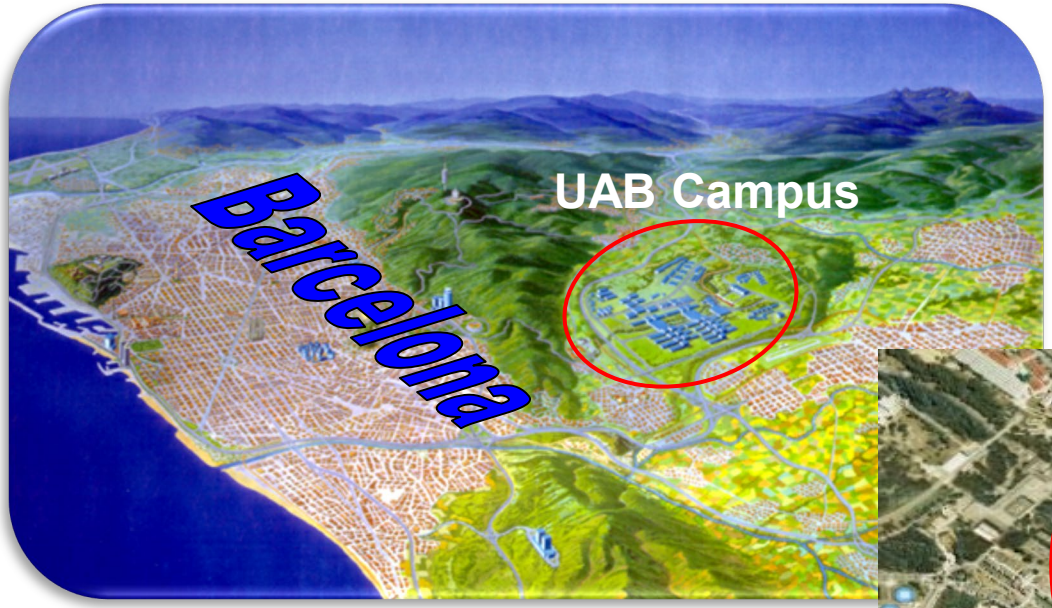
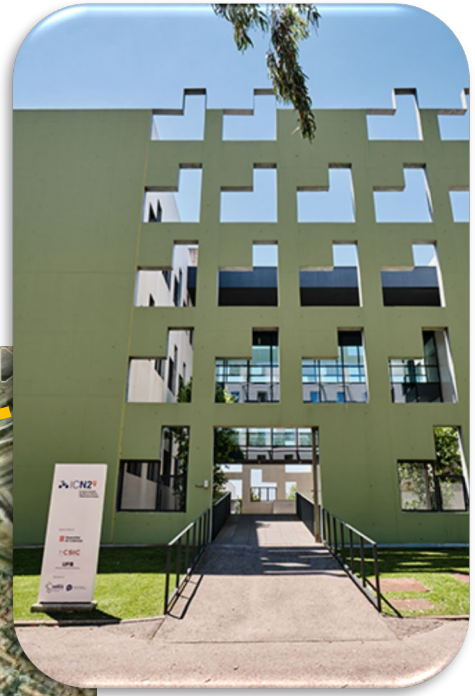
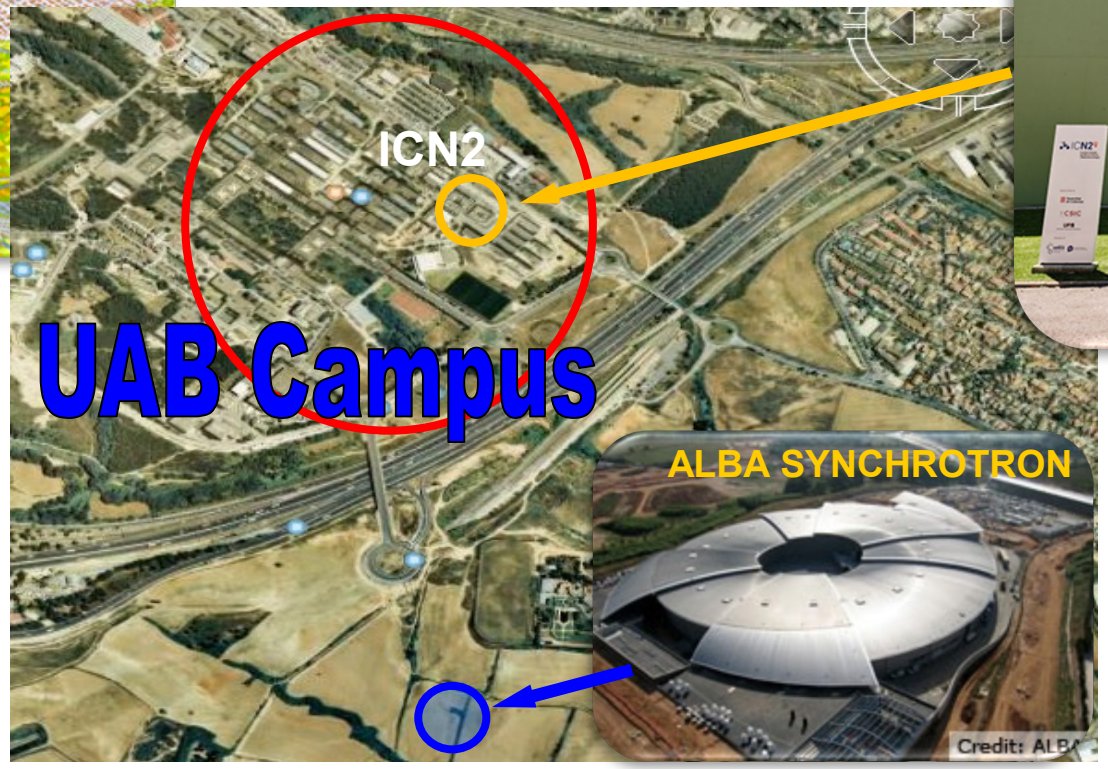
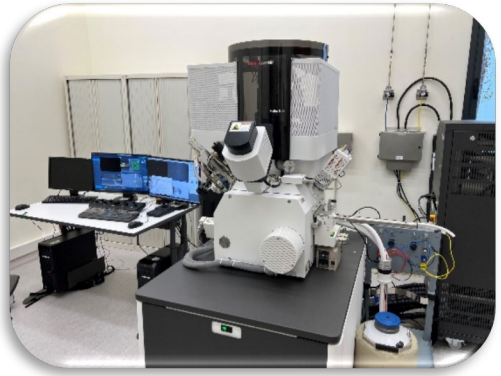
URL: www.gaen.cat







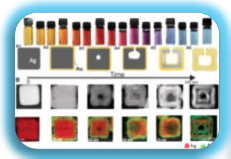


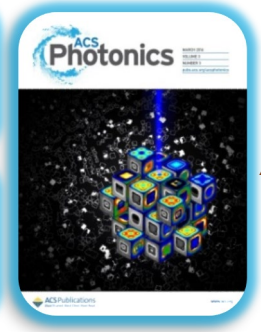
- ICN2 (CSIC & BIST)
- ALBA-CELLS

Unió Europea
Fons Europeu
de Desenvolupament Regional

Generalitat de Catalunya
Departament de Recerca i Universitats

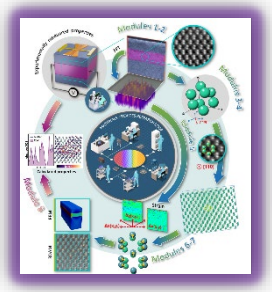
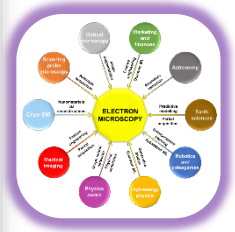
Research Lines





AI Data Analysis & Modelling

Nanoscale Horiz., **7**, 1427 (2022)
Adv. Intel. Syst., **7**, 2400986 (2025)
Adv. Mater., 10.1002/adma.202506785 (2026)
Adv. Intel. Syst., 10.1002/aisy.202501077 (2026)

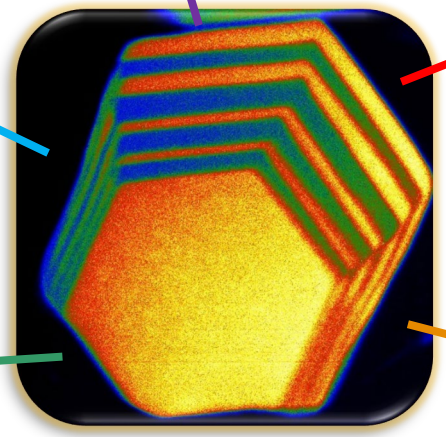



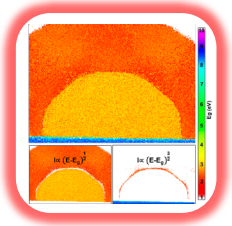
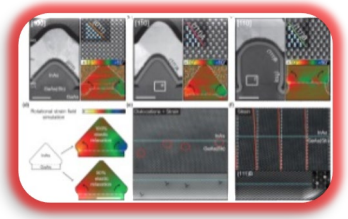
Nanowires, 2DEG & Quantum

Nature Mater., **20**, 1106 (2021)
Nature Commun., **13**, 4089 (2022)
Nature, **612**, 442 (2022)
Nature Commun., **14**, 7738 (2023)
npj Quantum Information, **10**, 32 (2024)
Nature Commun., **16**, 2103 (2025)
Adv. Funct. Mater., **35**, 2423734 (2025)

Metal NPs Bio & Photonics

Science, **334**, 1377 (2011)
Nanophoton., **6**, 193 (2017)
Nature Nanotech., **19**, 514 (2024)



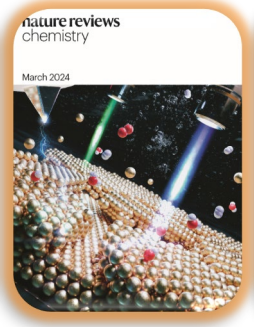




Nanostructures for Energy & Catalysis

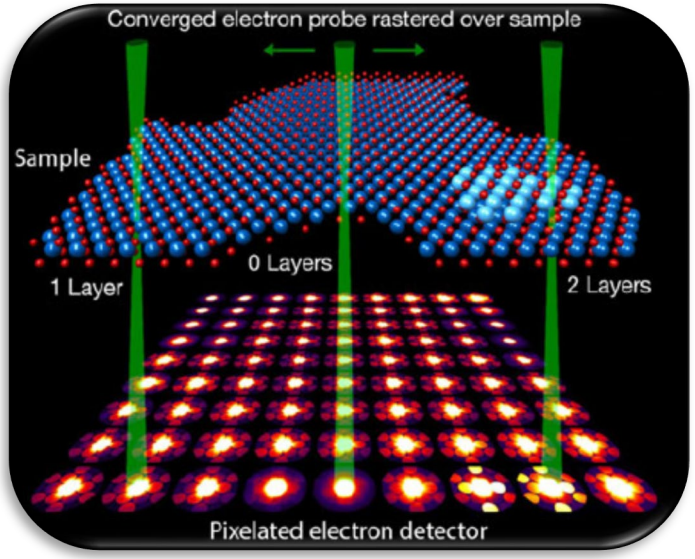
Nature Catalysis, **5**, 212 (2022)
Adv. Mater., **35**, 2306447 (2023)
Nature Rev. Chem., **8**, 159 (2024)
Adv. Mater., **36**, 2400810 (2024)
Adv. Mater., **36**, 2400572 (2024)
Science, **384**, 1373 (2024)
ACS Ener. Lett., **9**, 6178 (2024)
The Innovation, **6**, 100810 (2025)
Matter, **8**, 102139 (2025)
Adv. Mater., **38**, e11345(2026)

Oxides & Spintronics

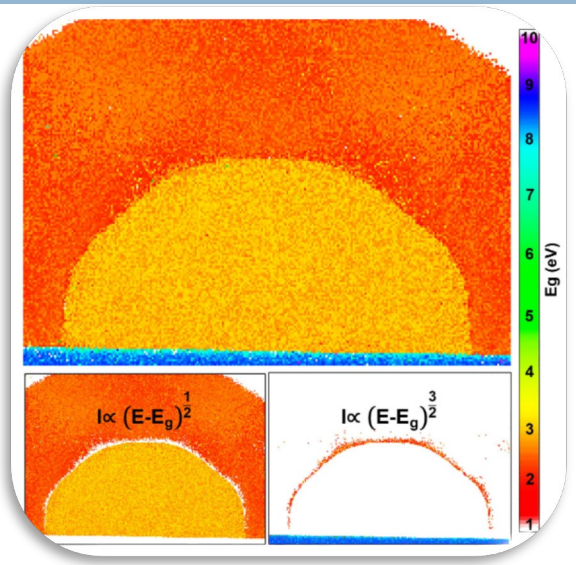
Nature Mater., **11**, 329 (2012)
Adv. Mater., **31**, 1905288 (2019)
PRL, **130**, 21680 (2023)
Nature Mater., **24**, 1359 (2025)



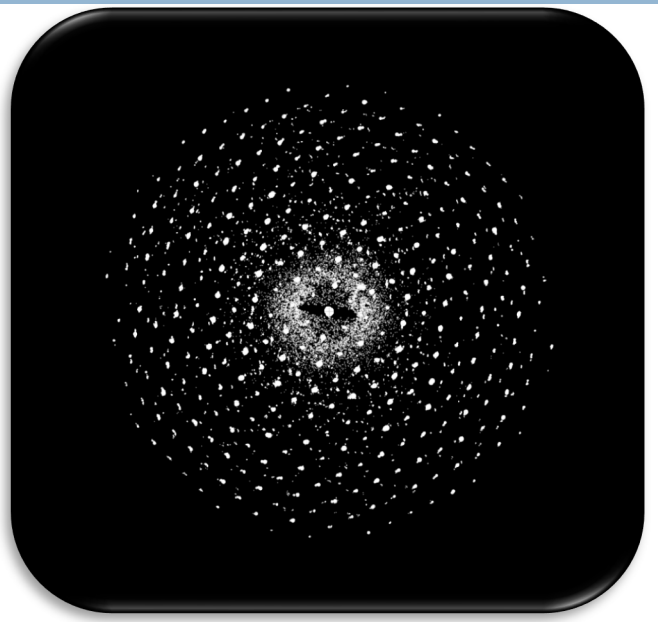
HR imaging, spectroscopy & diffraction

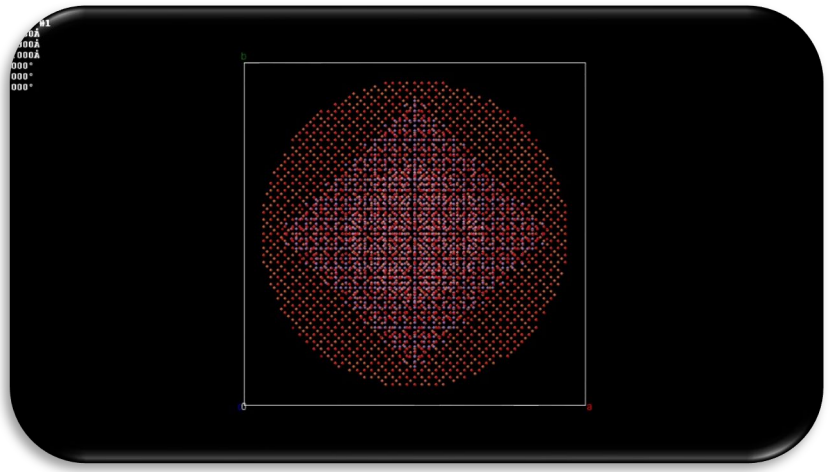


Microscopy & Microanal., **25**, 563 (2019)



Nature Commun., **13**, 4089 (2022)





ACS Nano, **8**, 2290 (2014)

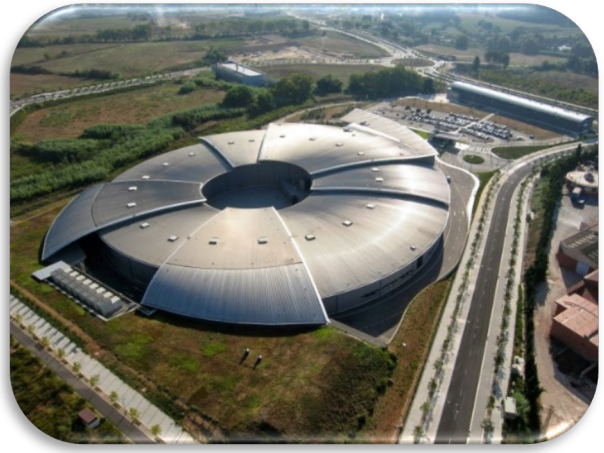
In Situ Correlative Facility for Advanced Energy Materials

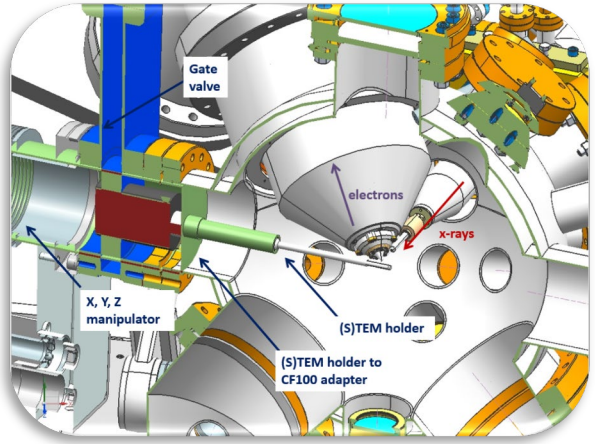
In-CAEM has developed a **singular infrastructure** for research in **advanced energy materials** in order to address the scientific challenges of the European Green Deal:

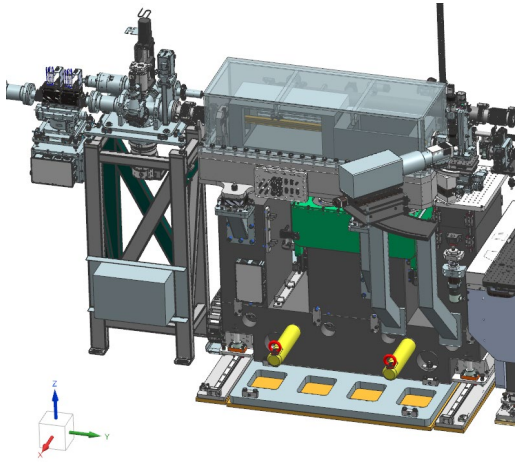
Multi-modal
Multi-lengthscale
Correlative

in situ/operando experiments, combining

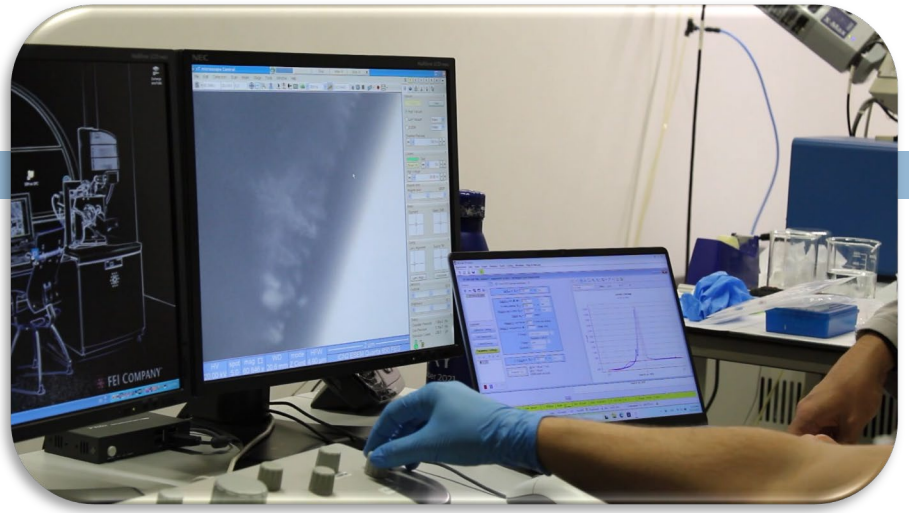
- **(Scanning) transmission electron microscopy**
- **Scanning probe microscopies**
- **Synchrotron X-rays** (spectroscopy, diffraction,…)
- **Advanced data analytics** (HPC, deep learning, AI,…)







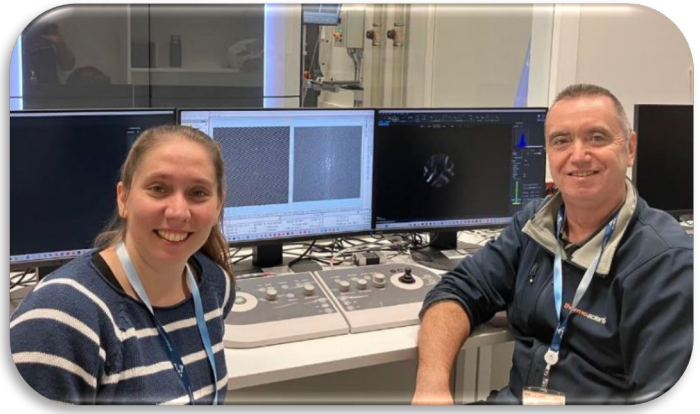
In-situ (S)TEM



- TFS Spectra 300 & ULTRA
- (AC)² & Monochromated (S)TEM:
  - 4D STEM (Empad & K3)
  - Super X & ULTRA EDX
  - Continuum K3 & ILIAD
- Catalysis sample holder system
  - Controlled gas mixing and flow
  - Controlled T + bias
  - RGA

Climate Infinity TEM holder

Cu(II) ↔ Cu (0) in-situ redox

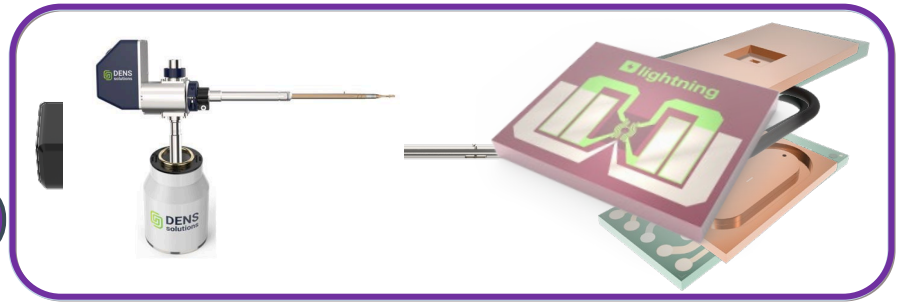


- Electrochemistry sample holder system
  - Liquid Flow
  - In-situ electrodes
  - Potentionstat
  - SEM echem cell

Stream Infinity TEM holder

- Liquid nitrogen cooling/heating/bias sample holder

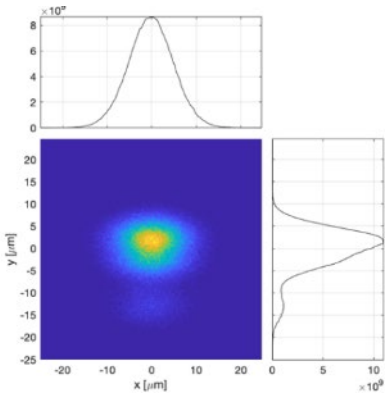
Lighting Arctic TEM holder

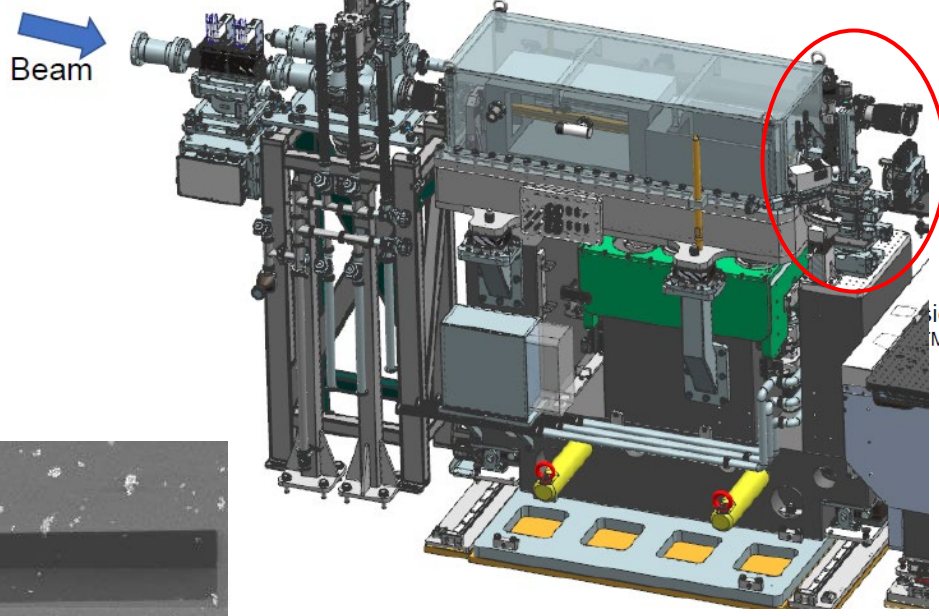


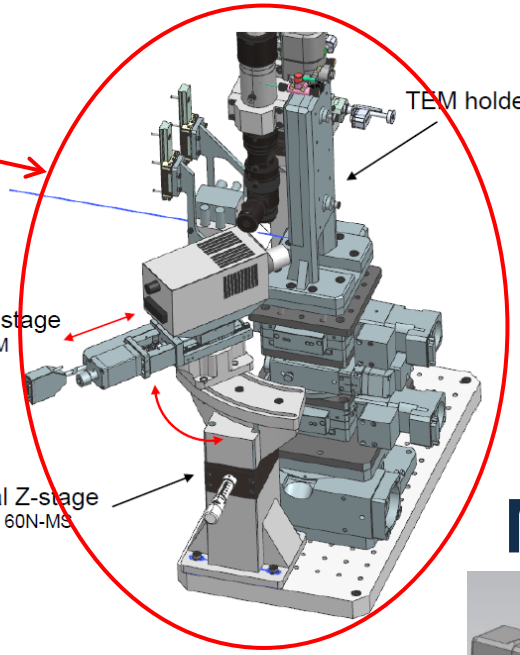
(S)TEM sample holder adapters for different BLs

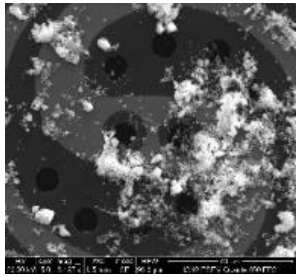
- μNOTOS: microspot XAS experimental station

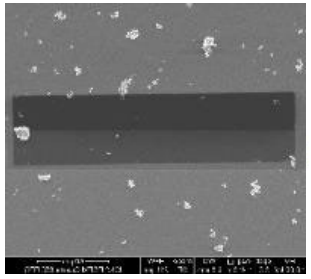
X-Rays ↔ (S)TEM



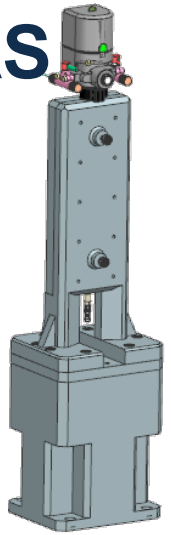




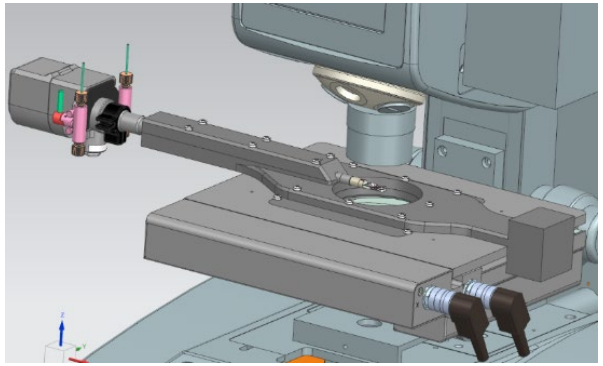




MIRAS



MSPD



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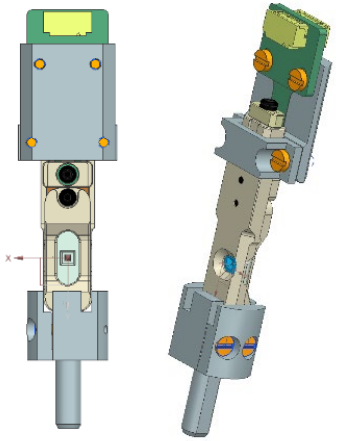
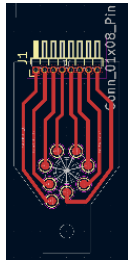
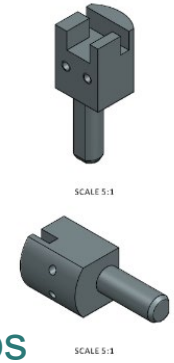
BL adaptations for correlative experiments

Automapping optical microscope
PEEM visualization system
BOREAS visualization system
Sample platelets
Platelet adapter AFMs
UHV suitcase
Laminar flow cabin
Metal sputtering system
Electropolishing system
Ar suitcase
Mistral TXM tip adapters

MISTRAL Transmission X-ray Microscope

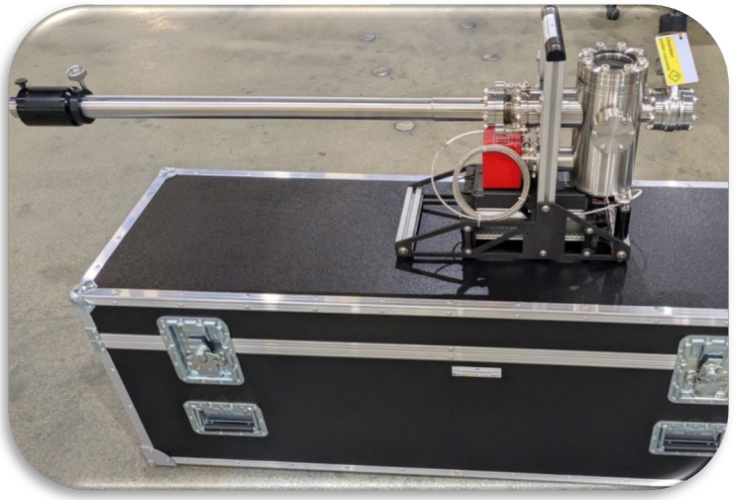




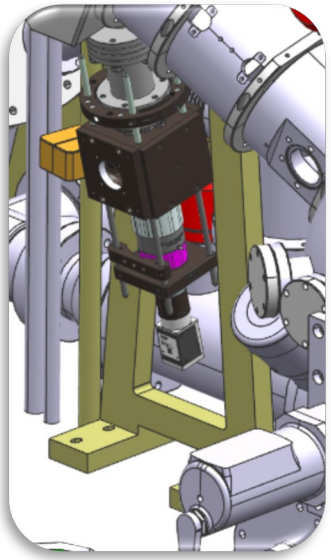


Arctic chips

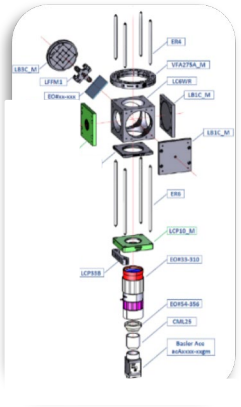
UHV suitcase



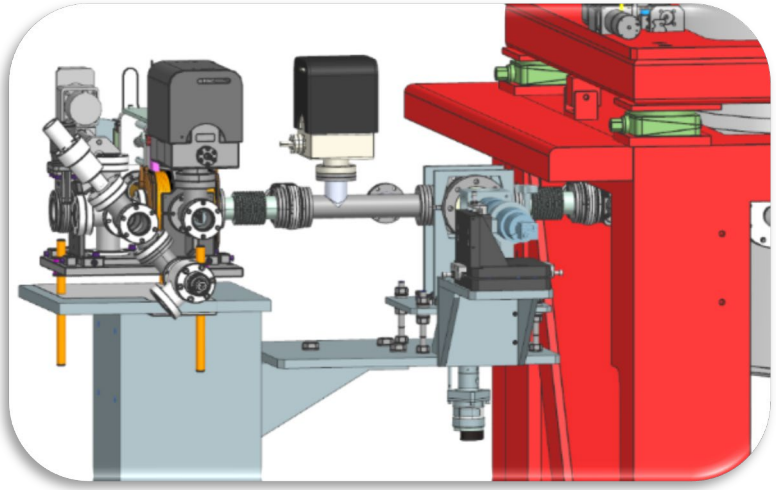
Climate & Stream nanoreactors



PEEM

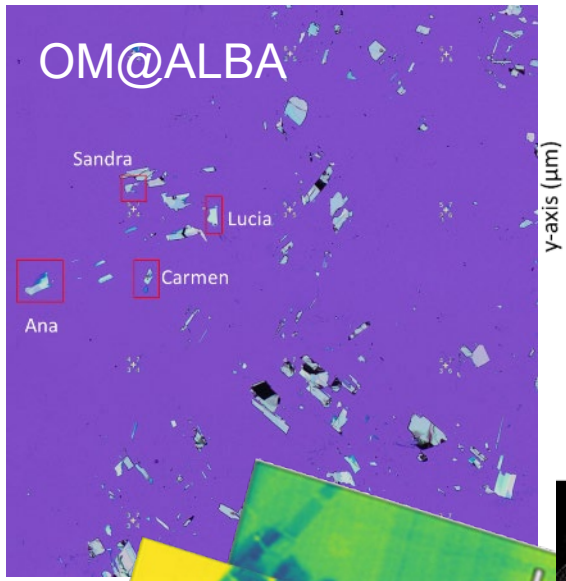


BOREAS

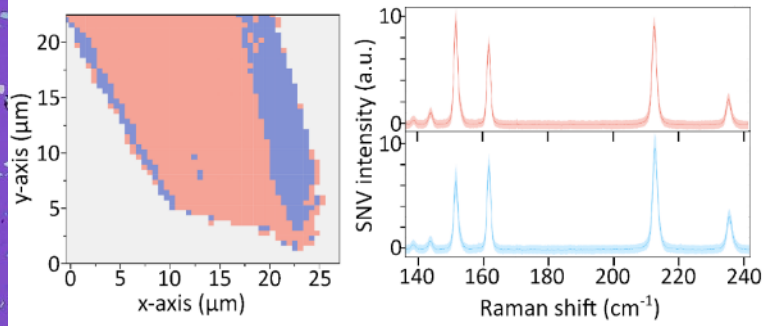


BL adaptations for correlative experiments

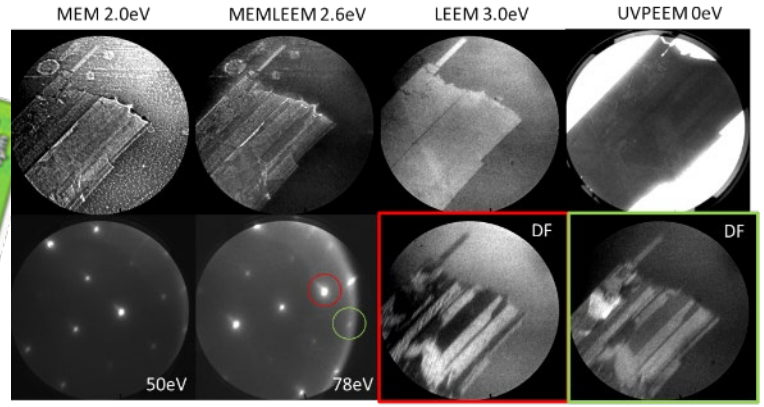
2D: ReS_2 flakes



KPFM@ICMAB

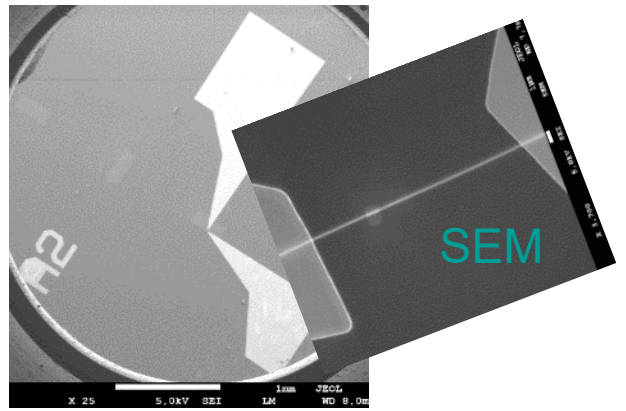


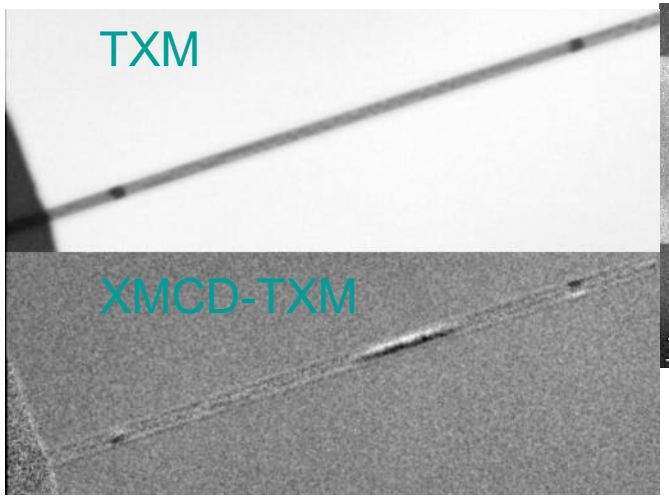
µRaman@ICN2

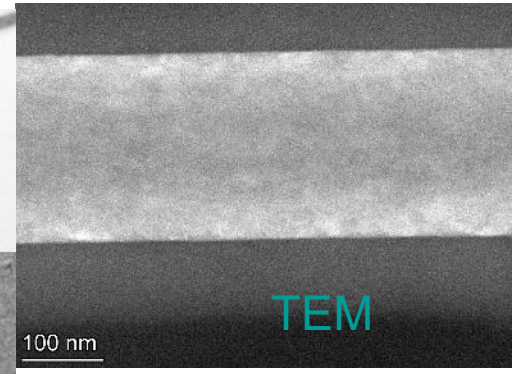


LEEM, UVPEEM & µLEED @ALBA

3D: Magnetic NWs



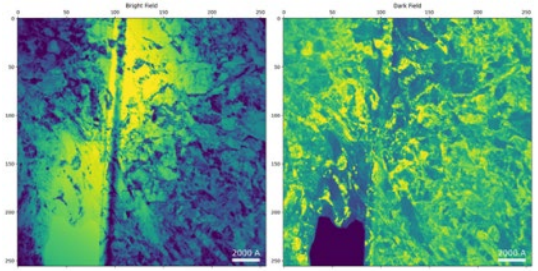




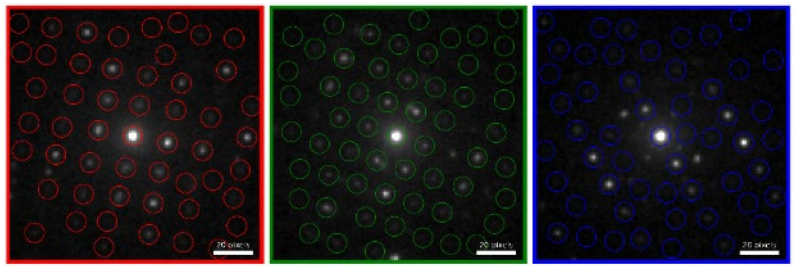
Automatic crystalline orientation mapping

ALBA methodology group

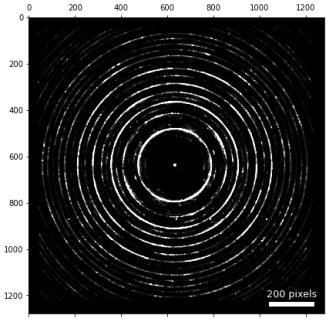
2-D histogram of e-diffraction spots coordinates, generate virtual diffraction pattern of overall region

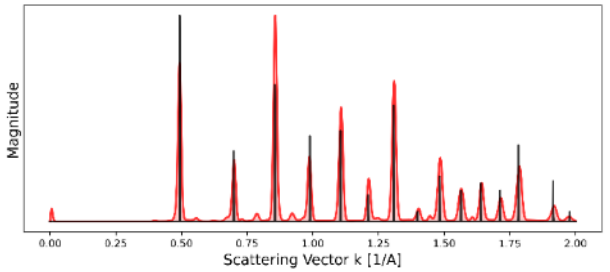


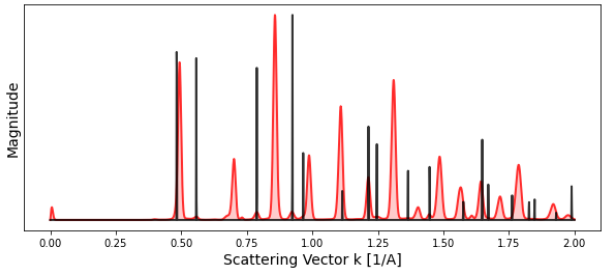
(MM1000)



Data: N. Bagués @METCAM

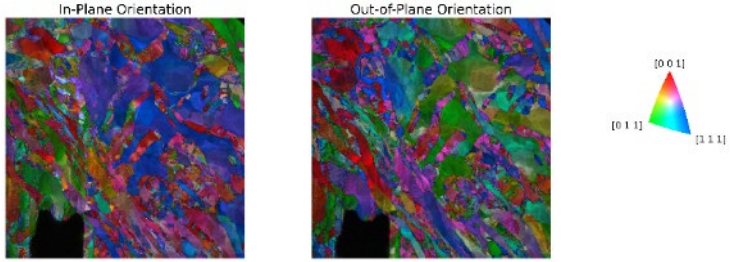




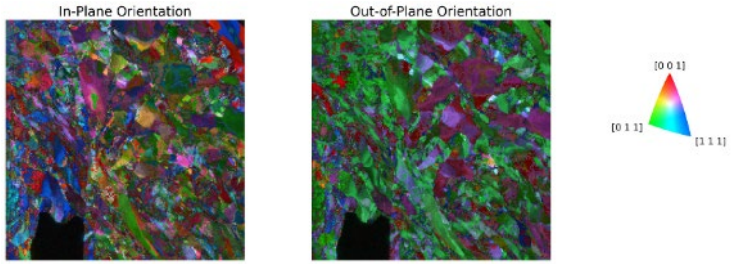


Azimuthal integration of the electron diffraction pattern of whole scanned region overlaid on BCC theoretical peaks

Orientation-map for BCC



Orientation-map for FCC



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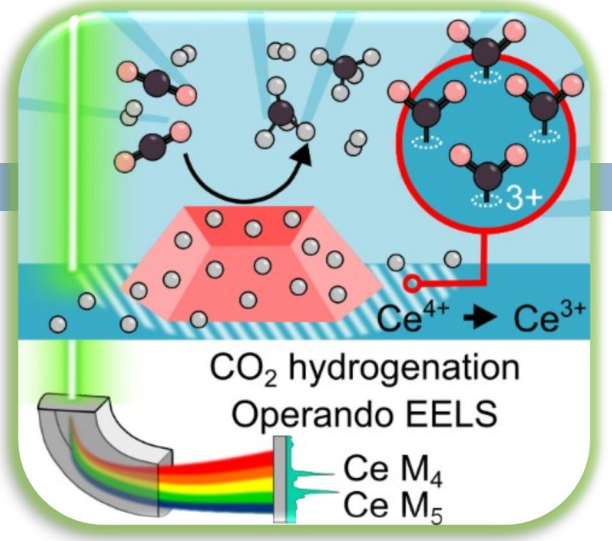
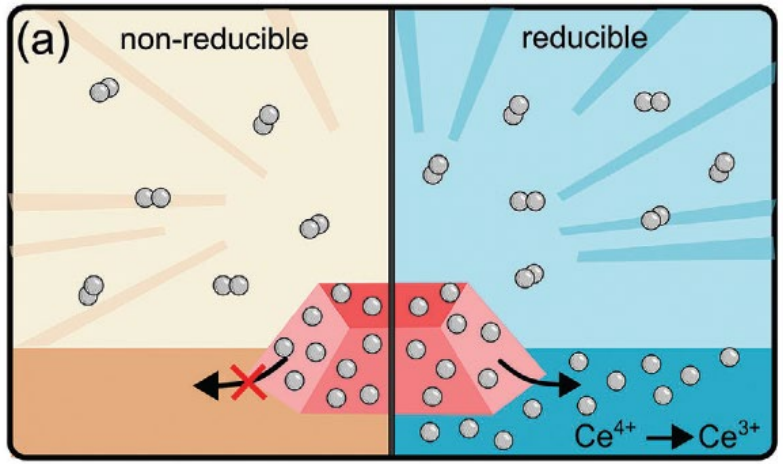
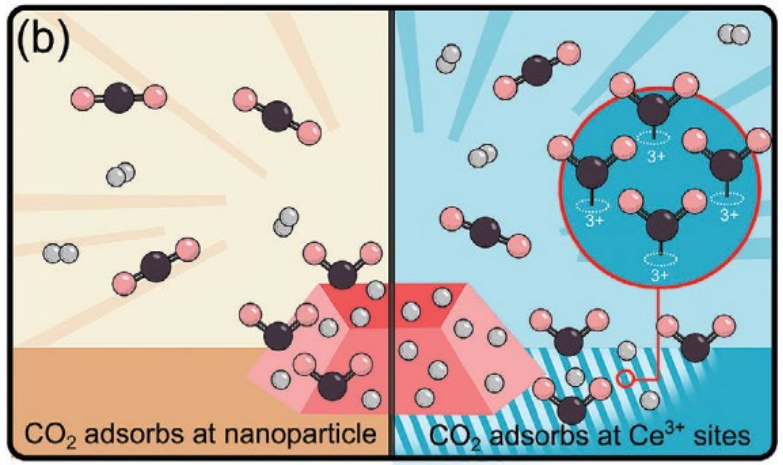
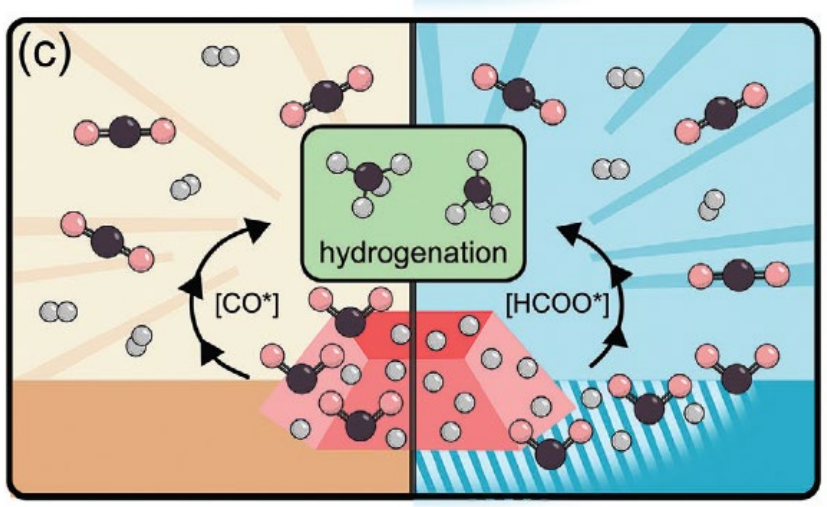
CO_2 in-situ methanation

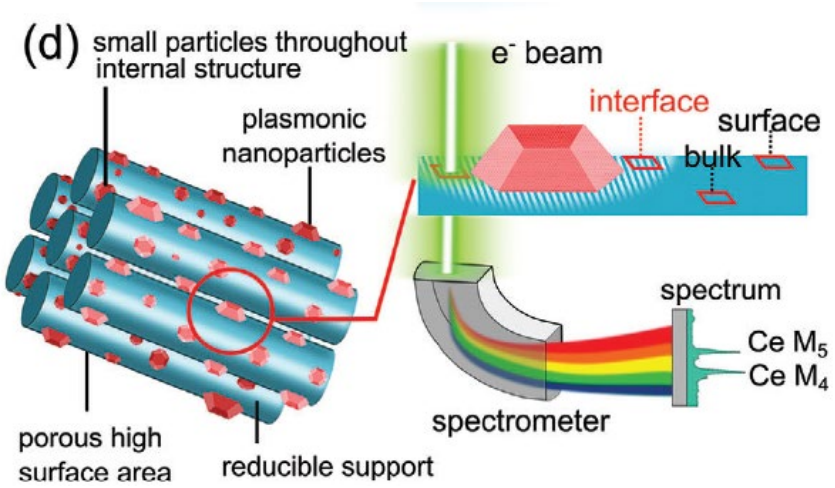


Thermally driven CO_2 methanation using Ni/CeO_2–based catalyst.









With: Universiteit Antwerpen; IREC Institut de Recerca en Energia de Catalunya, Catalonia Institute for Energy Research

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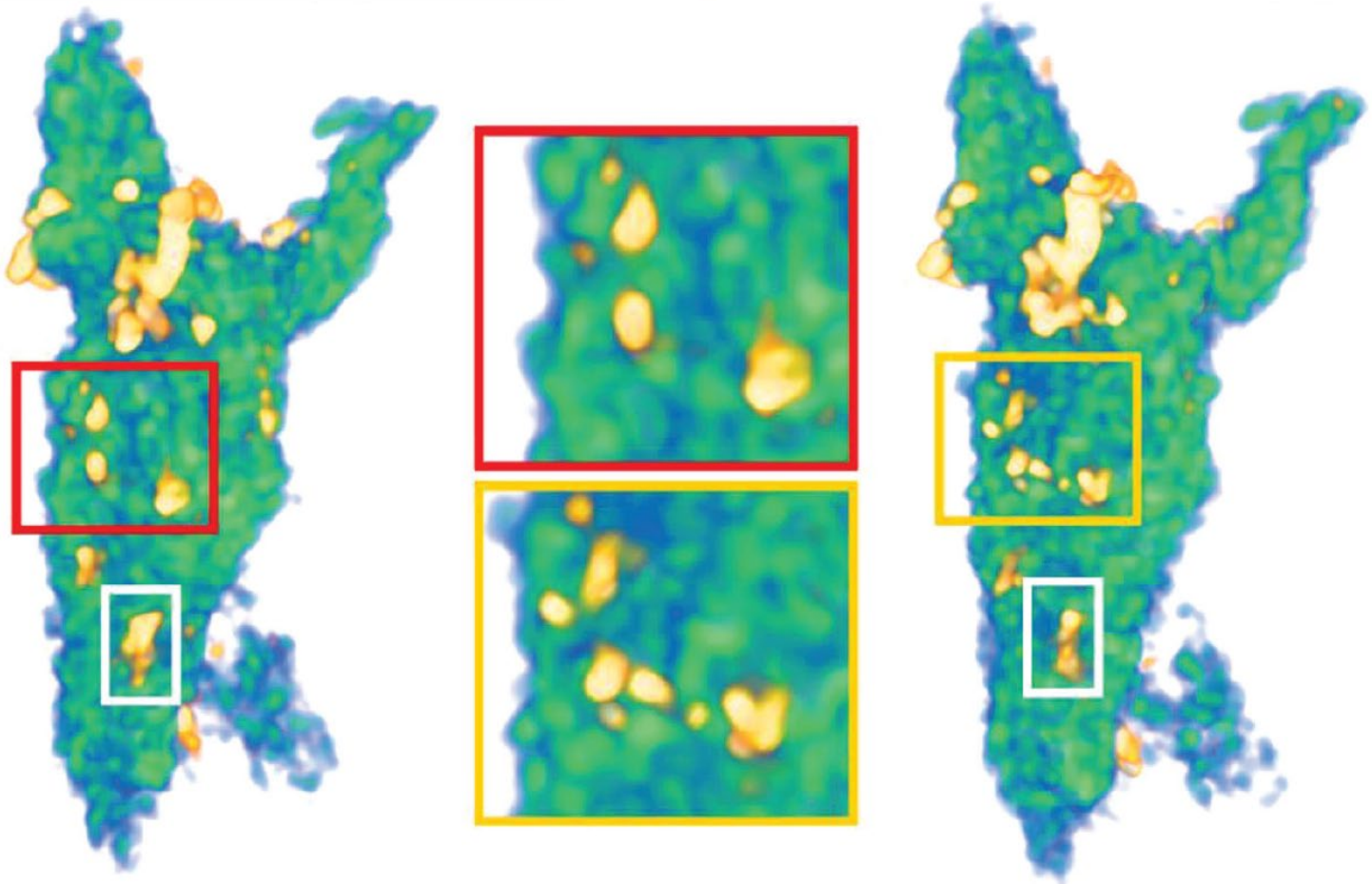
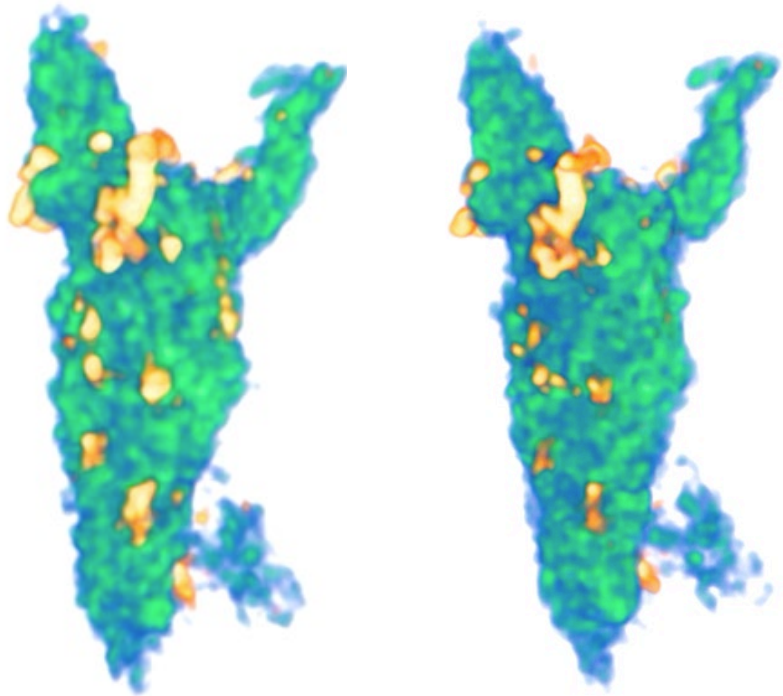
EDX Tomography

In Situ Heating Tomography on a DENSsolutions Wildfire heating holder





Before heating

After heating
350 degrees 15 minutes

There is a variation in volume of Ni NPs on the surface after heating.
Positions of individual nanoparticles do not change.

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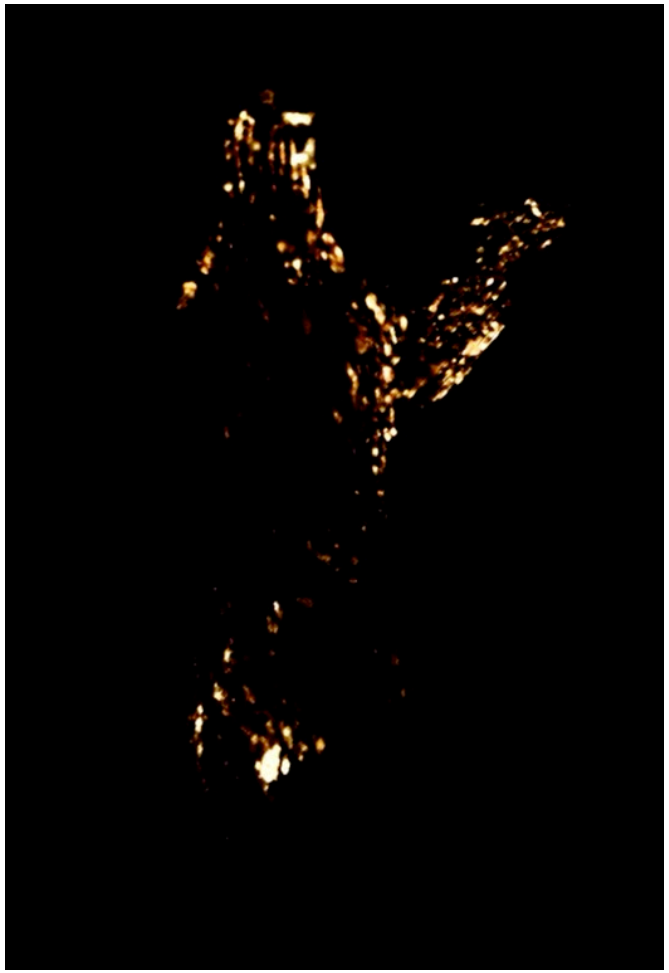
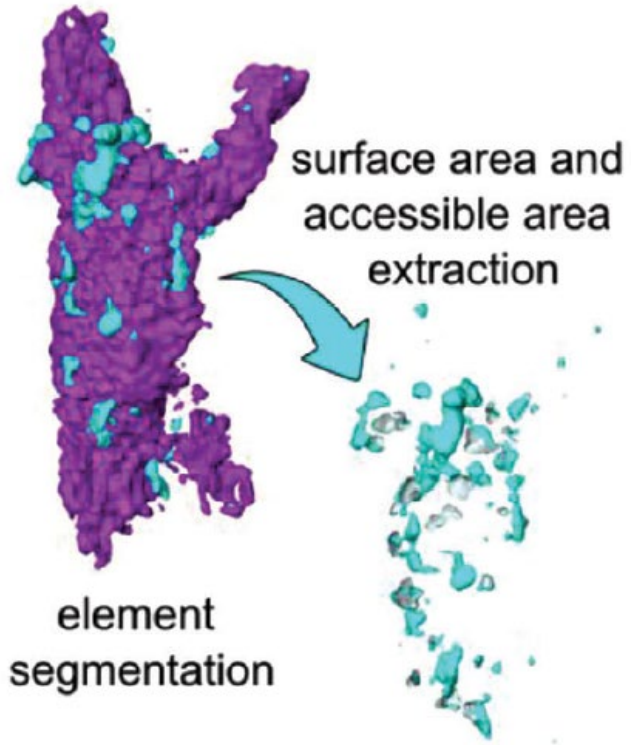
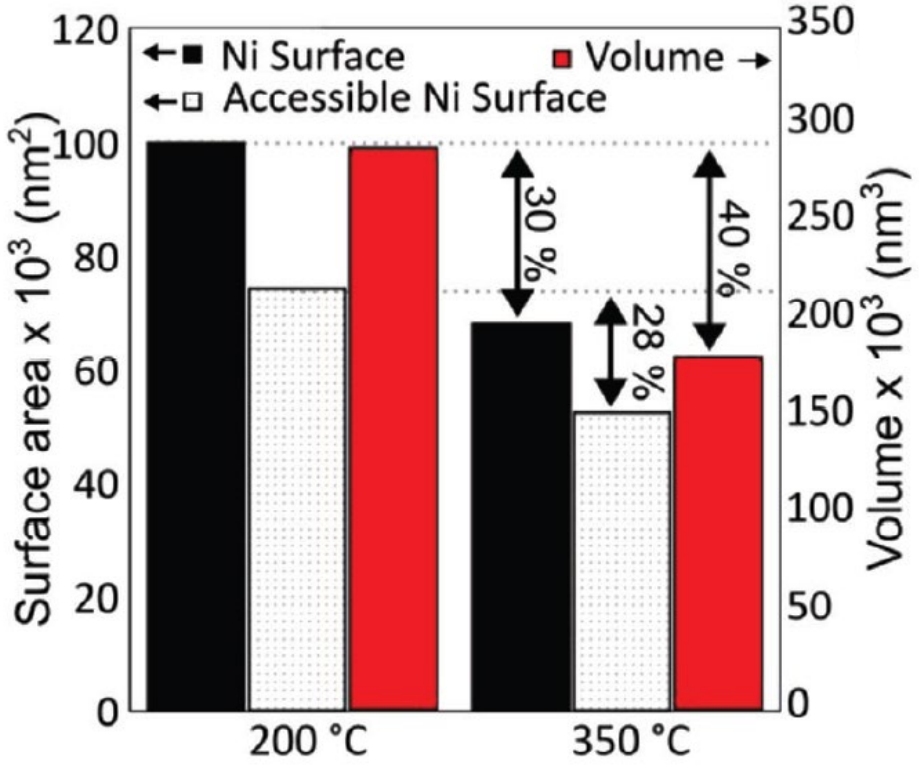
Volume Change Upon Heating

In Situ Heating Tomography on a DENSsolutions Wildfire heating holder



Volume lost after heating





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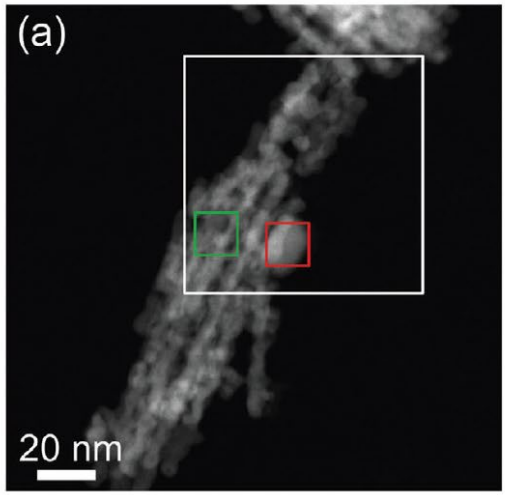
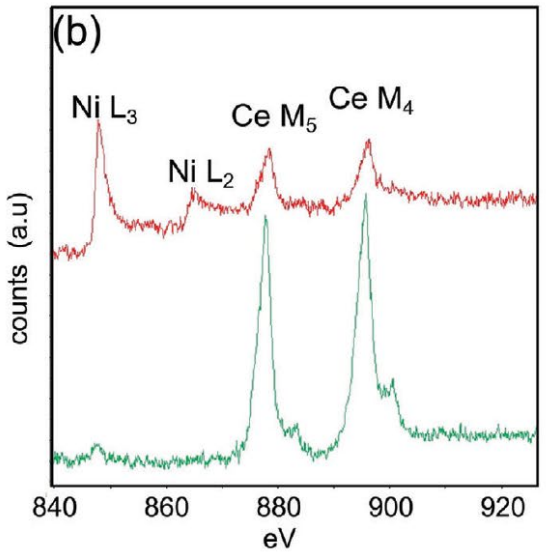
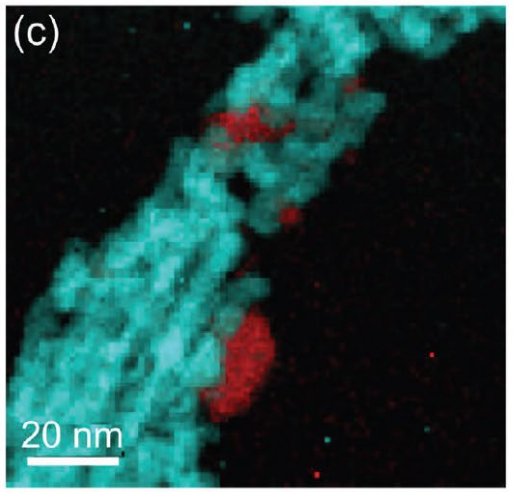
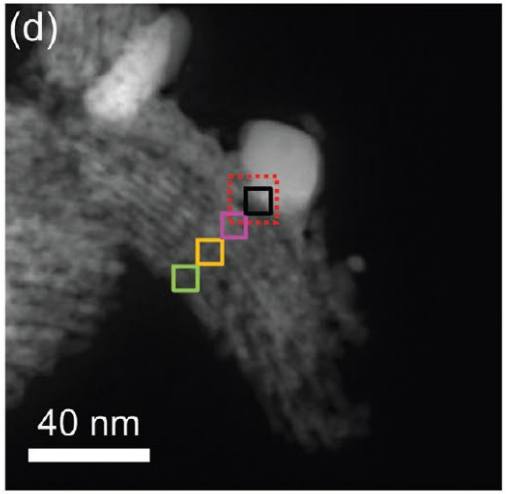
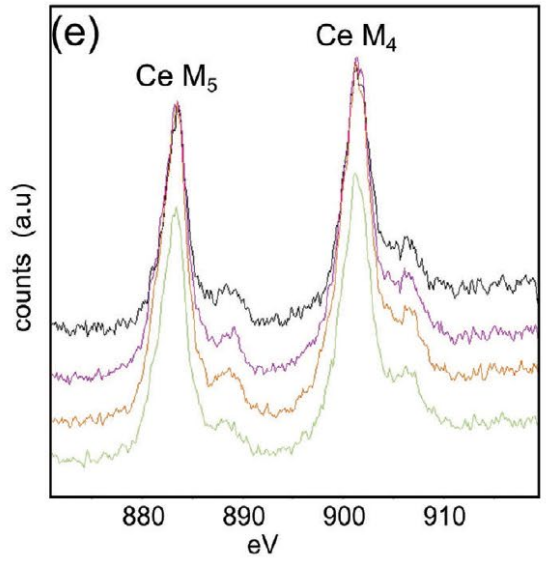
Ceria oxidation state during heating

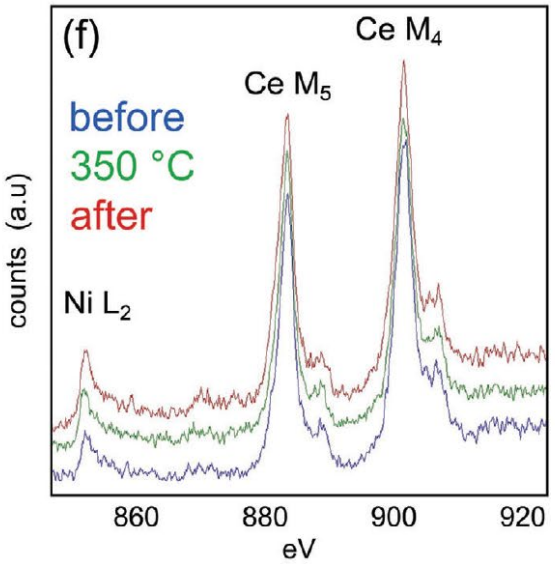












In situ heating EELS analyses

EEL spectra compared from the near and far regions with respect to the Ni NP reveal no variation in Ce oxidation state based on proximity to Ni NPs. During this acquisition, the catalyst was heated to 120 °C to minimize carbon contamination.

Ce3+ abundance does not increase at elevated temperatures and still remains independent to Ni proximity at 400 °C.

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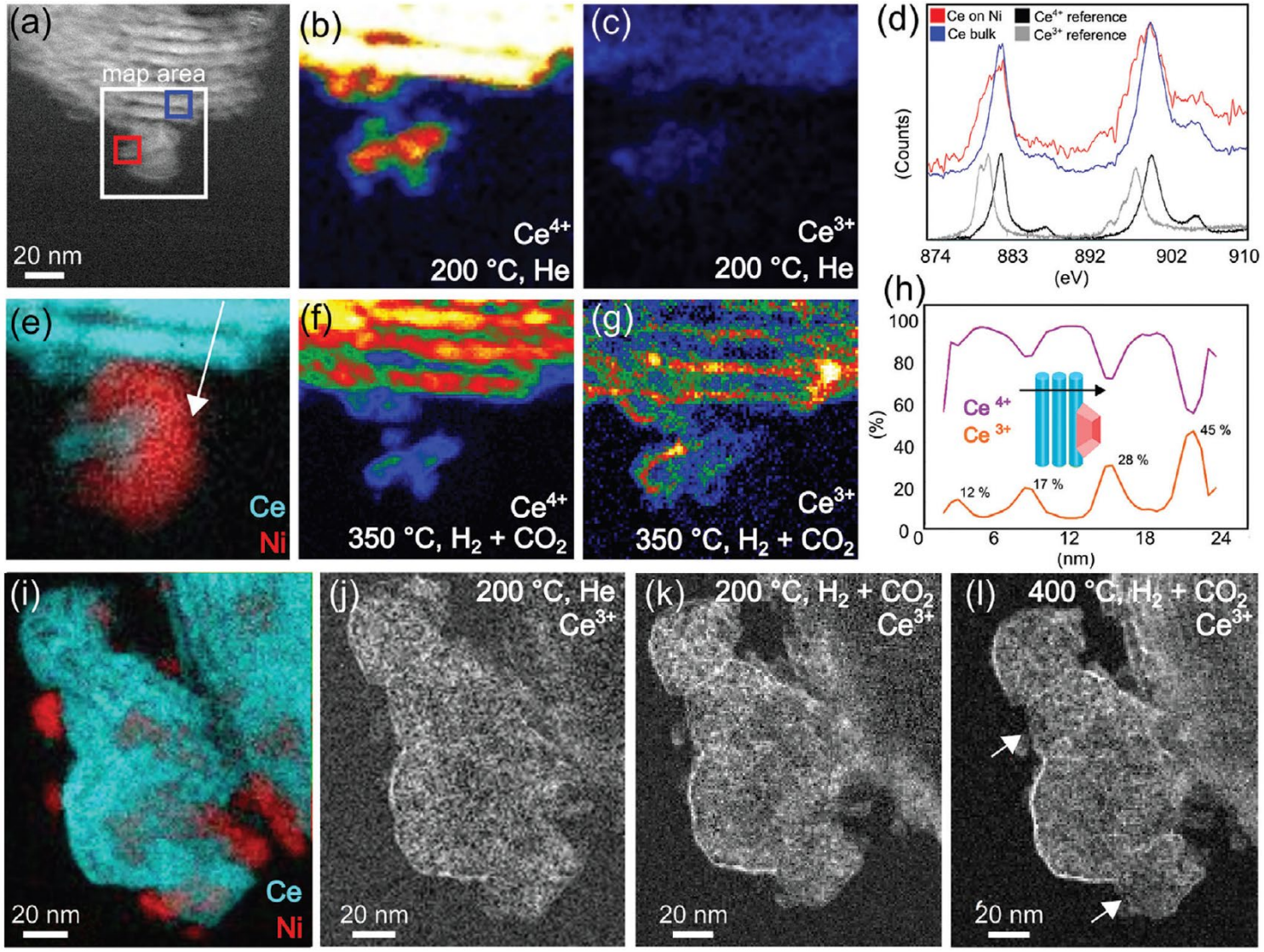
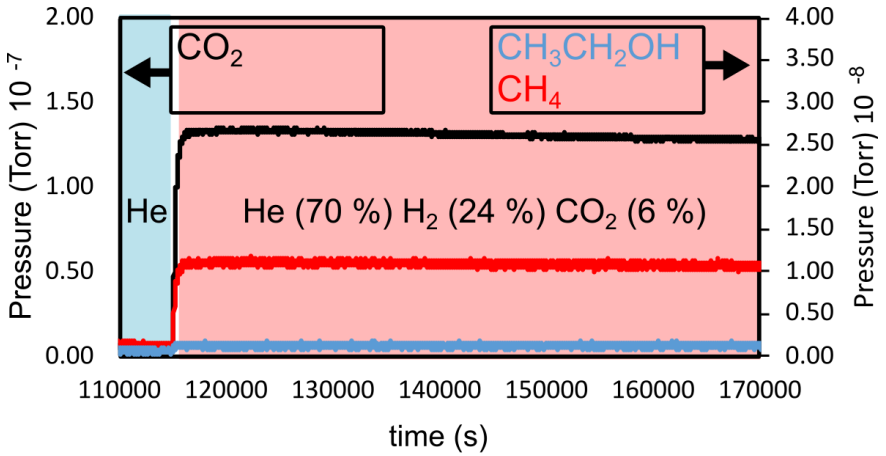
CO_2 in-situ methanation



Operando electron energy loss spectroscopy (EELS) of Ni/MP-CeO2 under hydrogenation conditions.

In a DENSsolutions Climate G+ with a nanocell reactor.

Sample at 350ºC under CO_2:H_2:He atmosphere. Oxidation state maps suggest an increase in Ce^{3+} close the Ni nanoparticle



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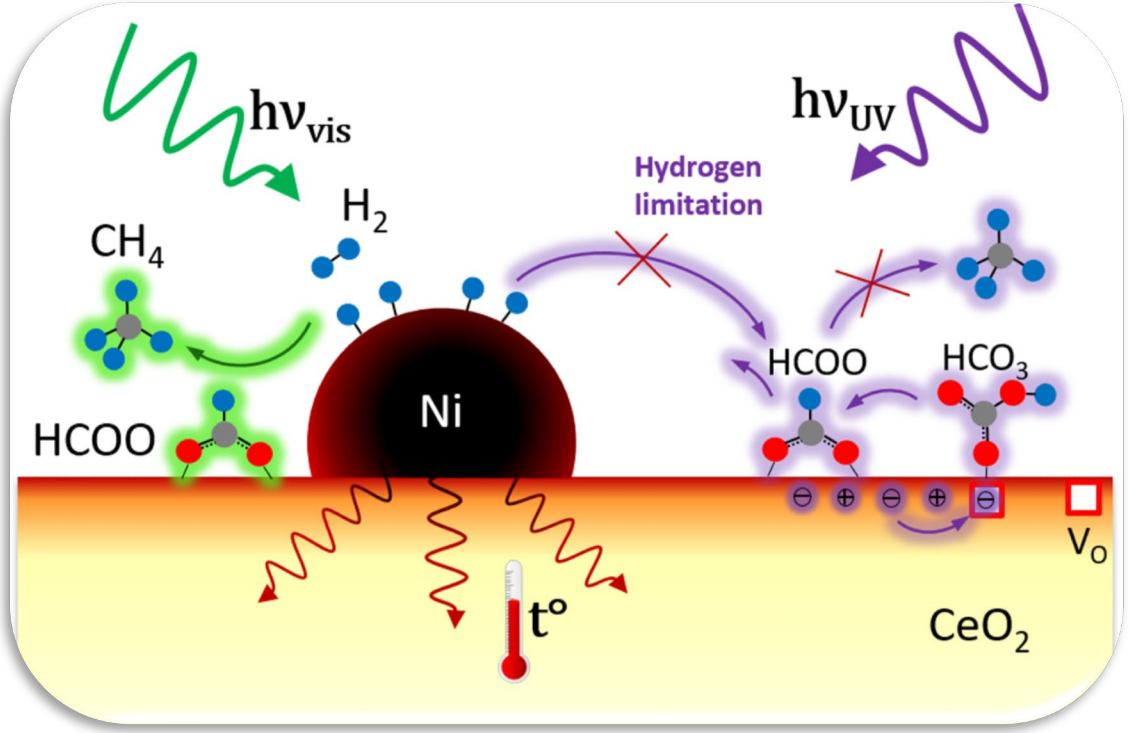
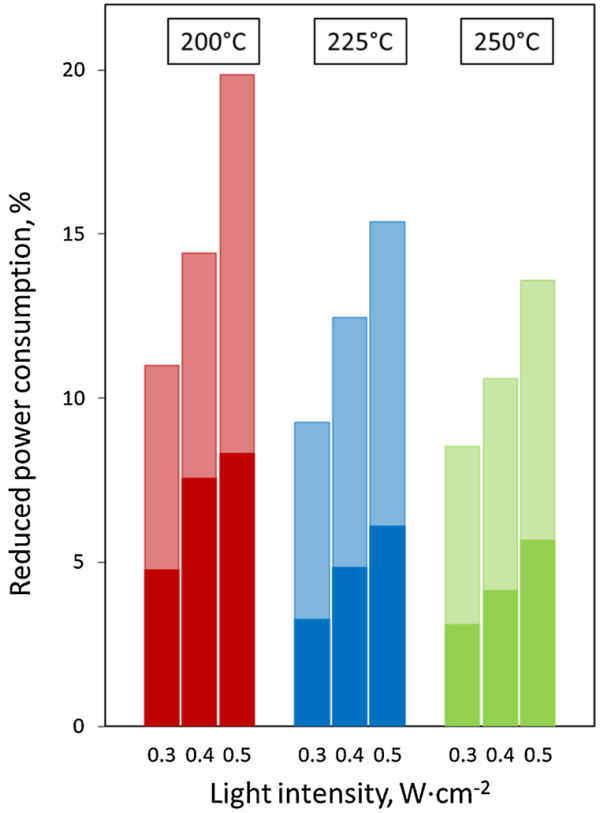
CO_2 in-situ methanation

Next Steps: Effects of solar irradiation on thermally driven CO_2 methanation using Ni/CeO_2–based catalyst.





Plasmonic Activated Ni/CeO2 Nanoreactors x2.4 activity under Sunlight

With: Universiteit Antwerpen; IREC Institut de Recerca en Energia de Catalunya, Catalonia Institute for Energy Research

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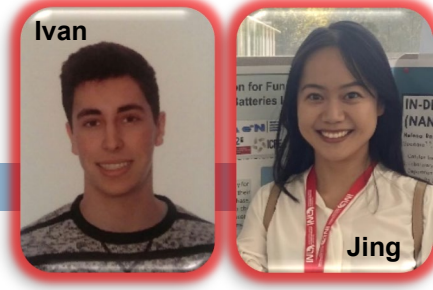
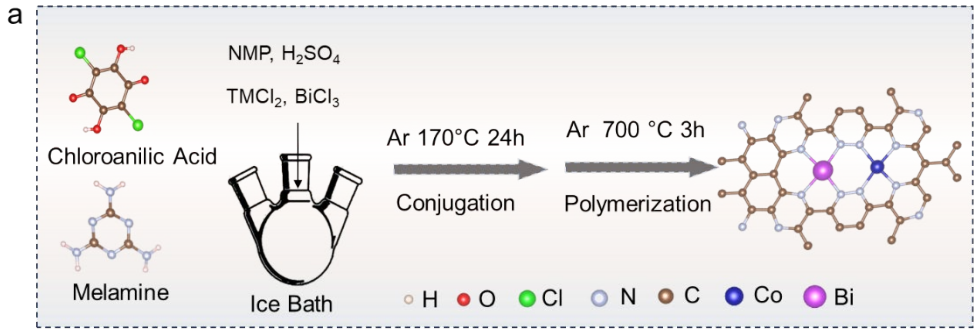
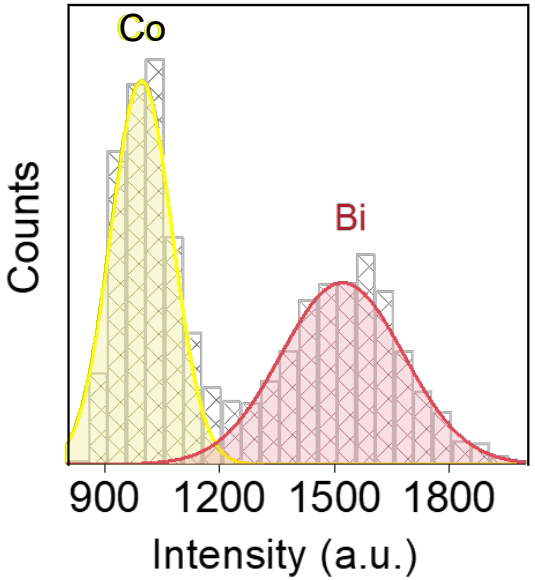
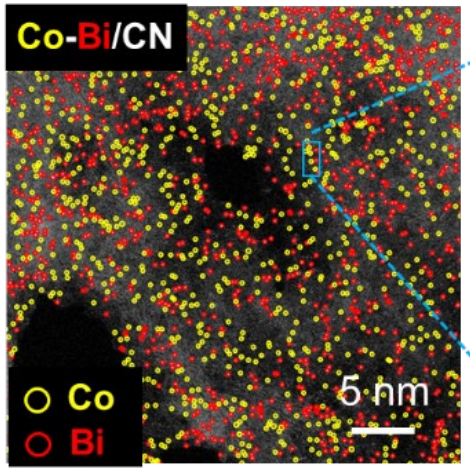
Automated AI-enhanced STEM data analysis in correlation to XAS

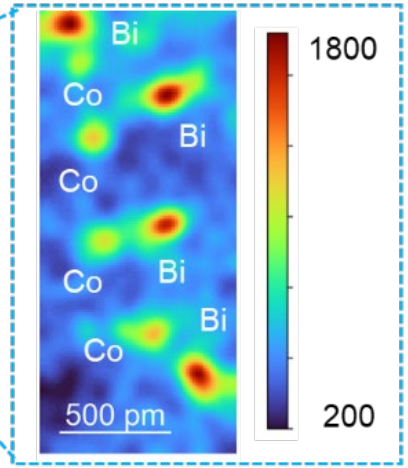


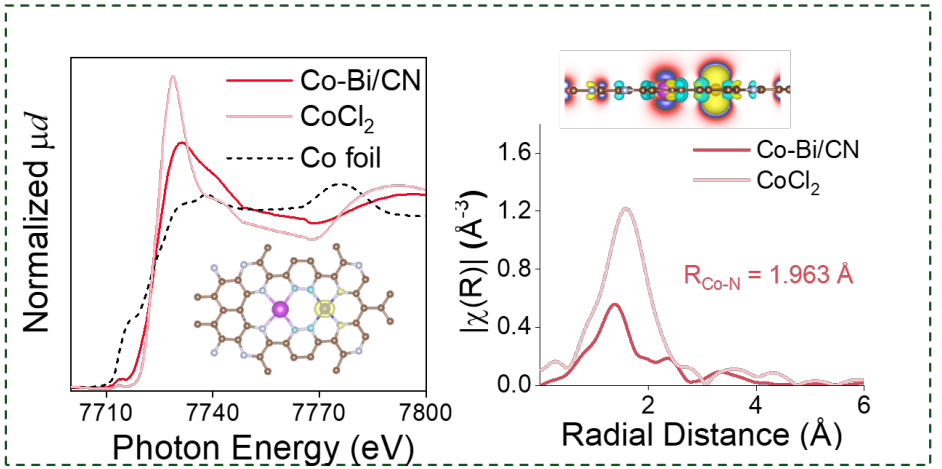


Promoting Electrochemical Reactions with Dual-Atom Catalysts for High-Rate Lithium-Sulfur Batteries









Physicochemical characterization of TM-Bi/CN DACs using a Laplacian of Gaussian algorithm

32% coupled Co-Bi pairs
31% either Bi-Bi or Co-Co pairs
37% existed as isolated Co or Bi atoms

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Why Dual-Atom Catalysts (DACs)?

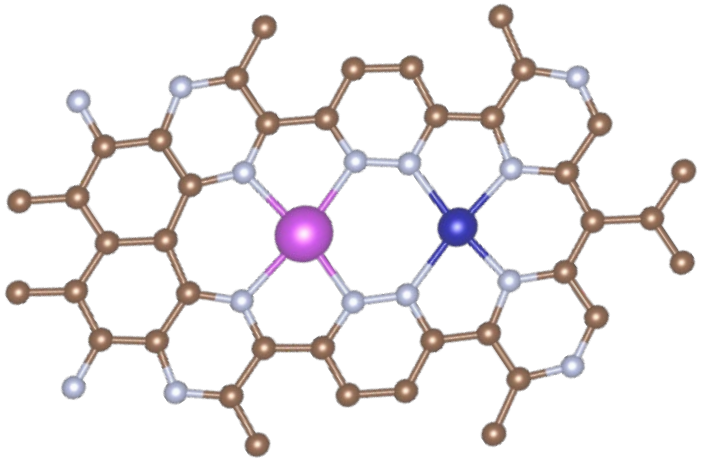
SACs

- Maximized atomic utilization efficiency
- Unique electronic structures
- Superior activity and selectivity

DACs

- Better tunability
- Inherent asymmetry
- Broader compositional flexibility
- The potential synergistic effects

1+1>2?



- Dual-atoms catalysts additive design;
- Promoted SRRs;
- Metal utilization—0.2%

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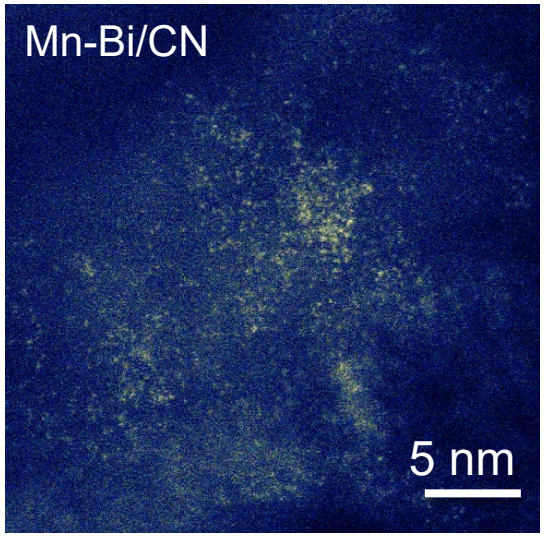
Atomic-Scale Structural Identification

a



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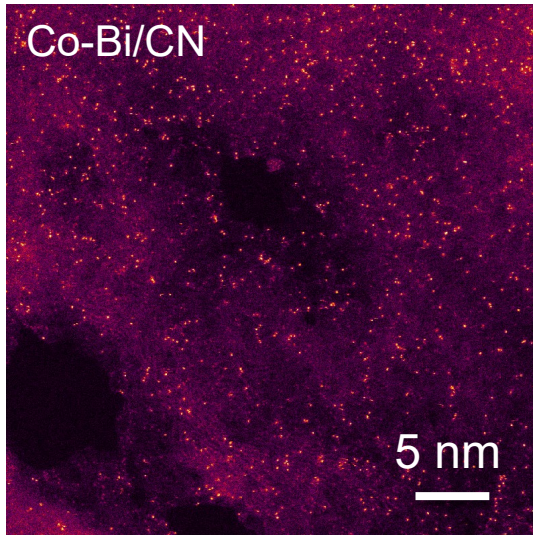

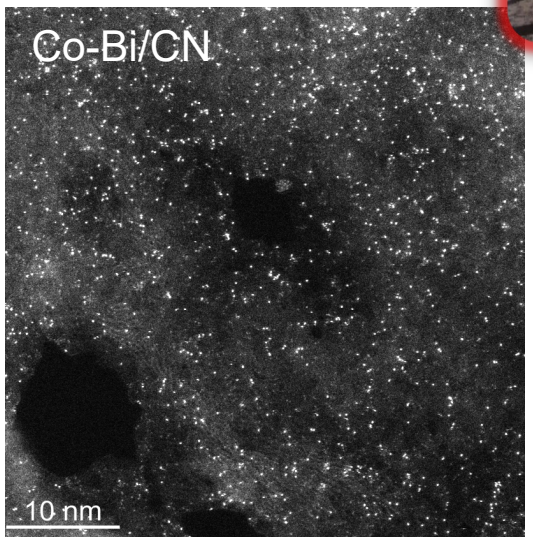

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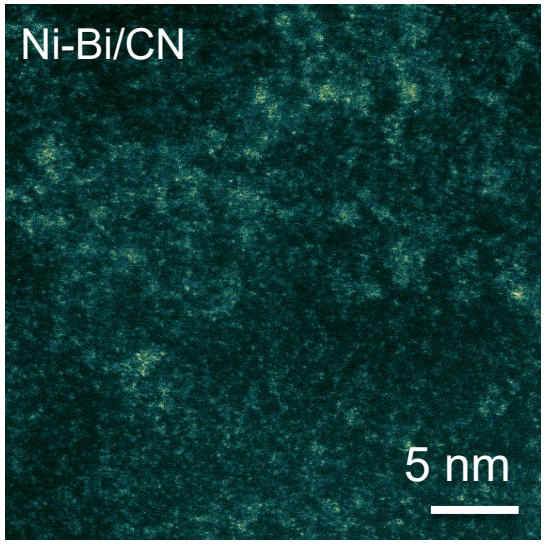

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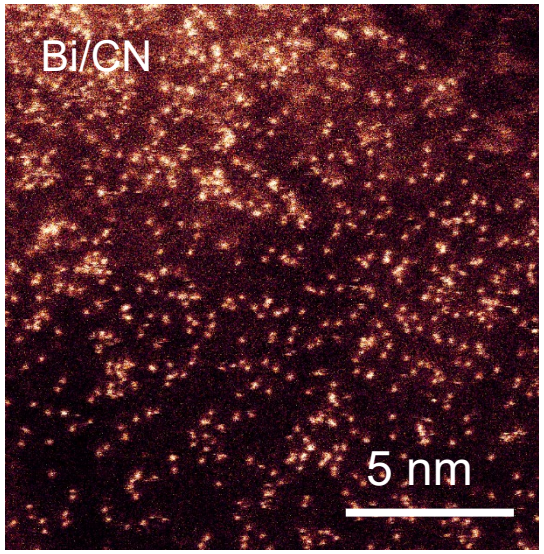

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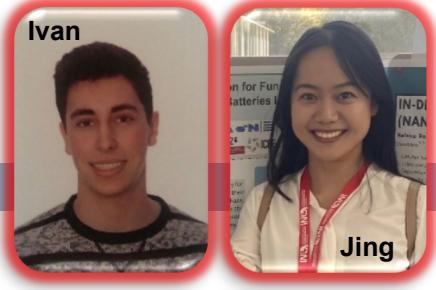
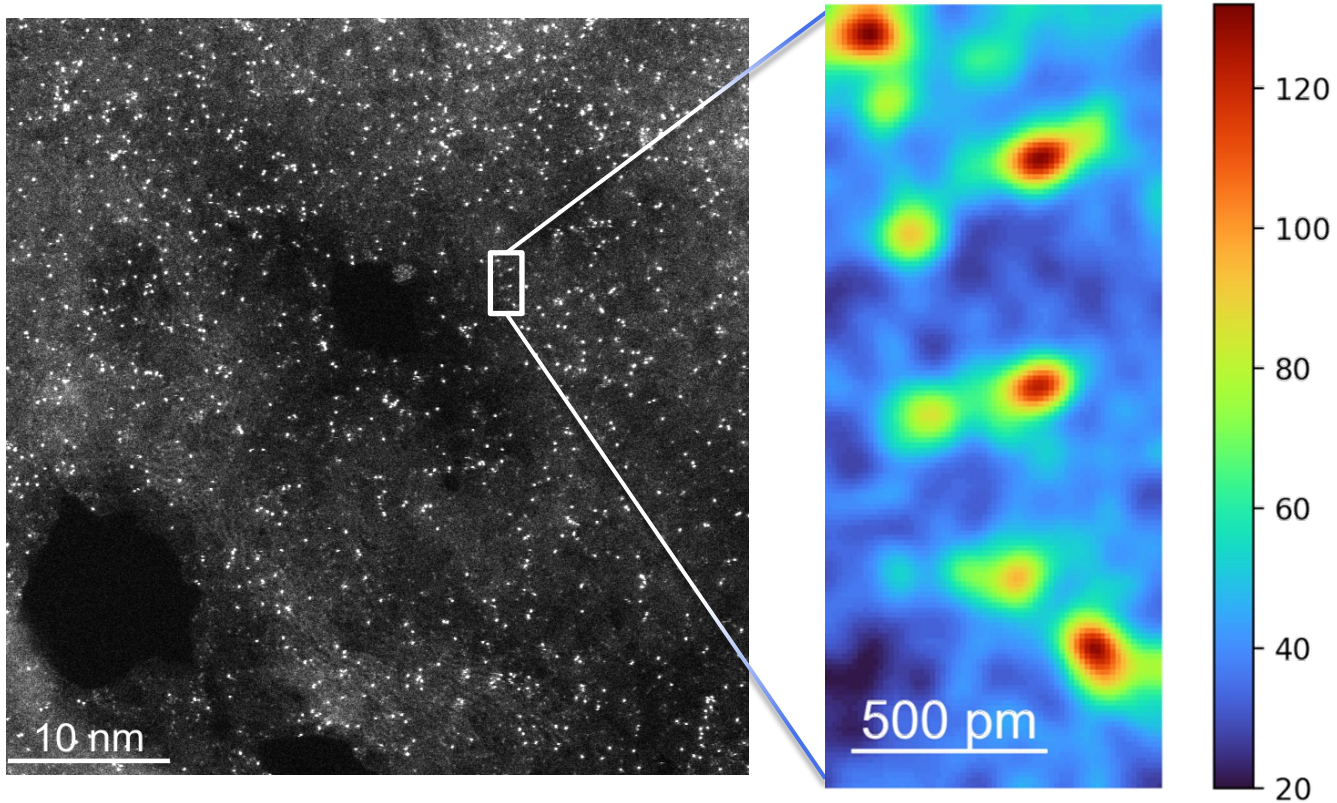
Atomic-Scale Structural Identification





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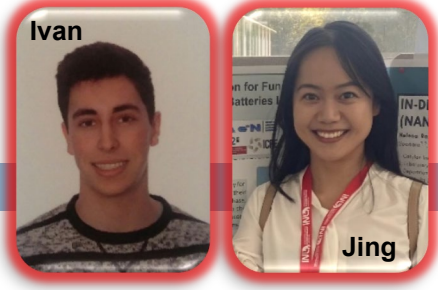
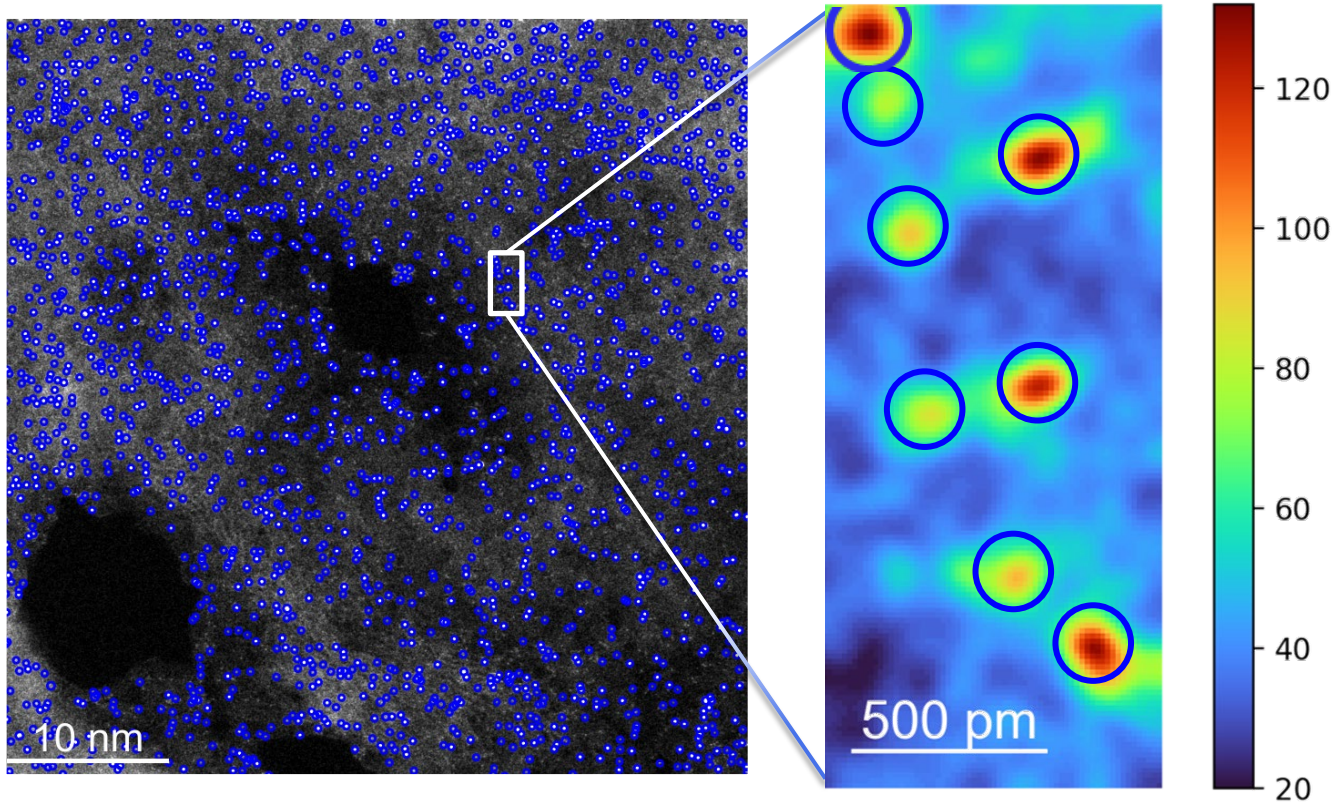
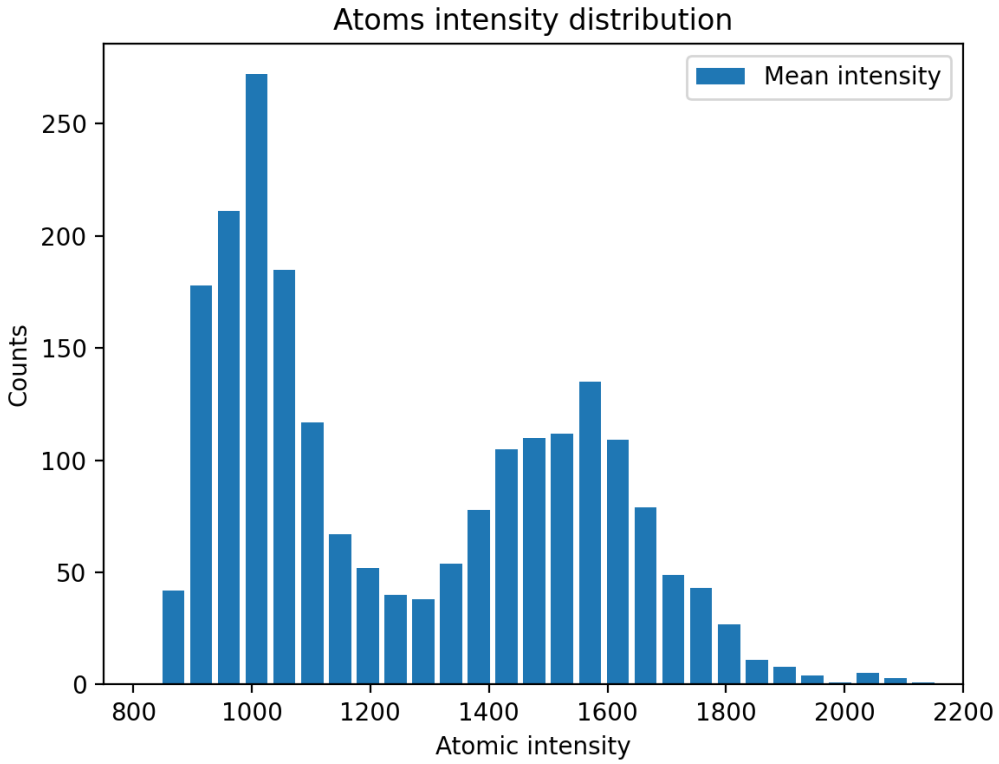
Atomic-Scale Structural Identification



Atomic position





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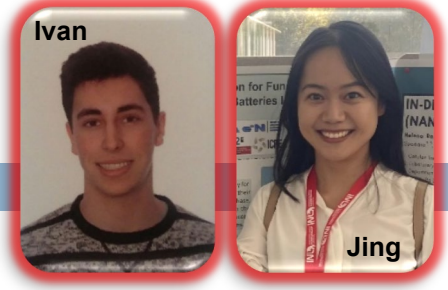
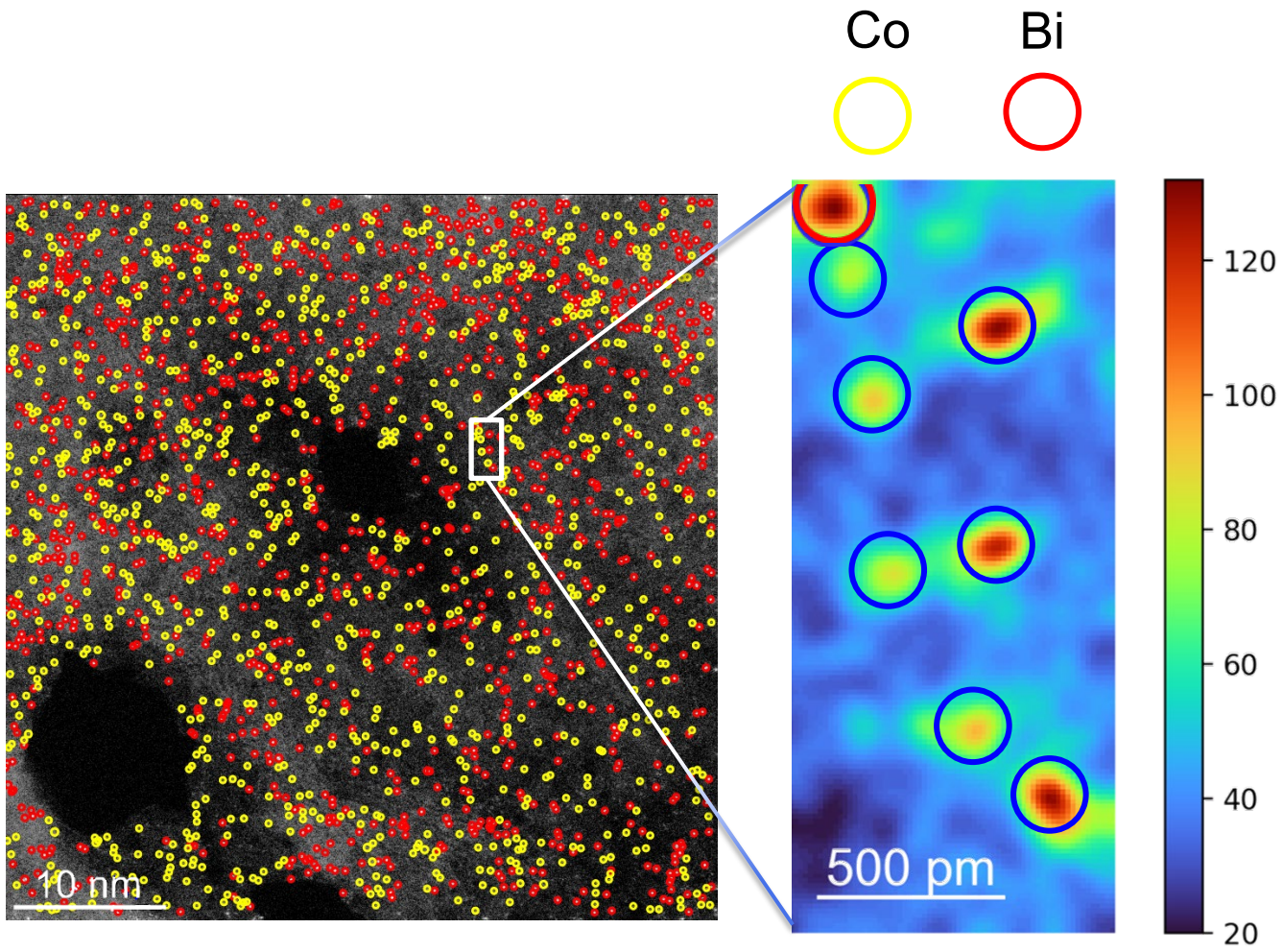
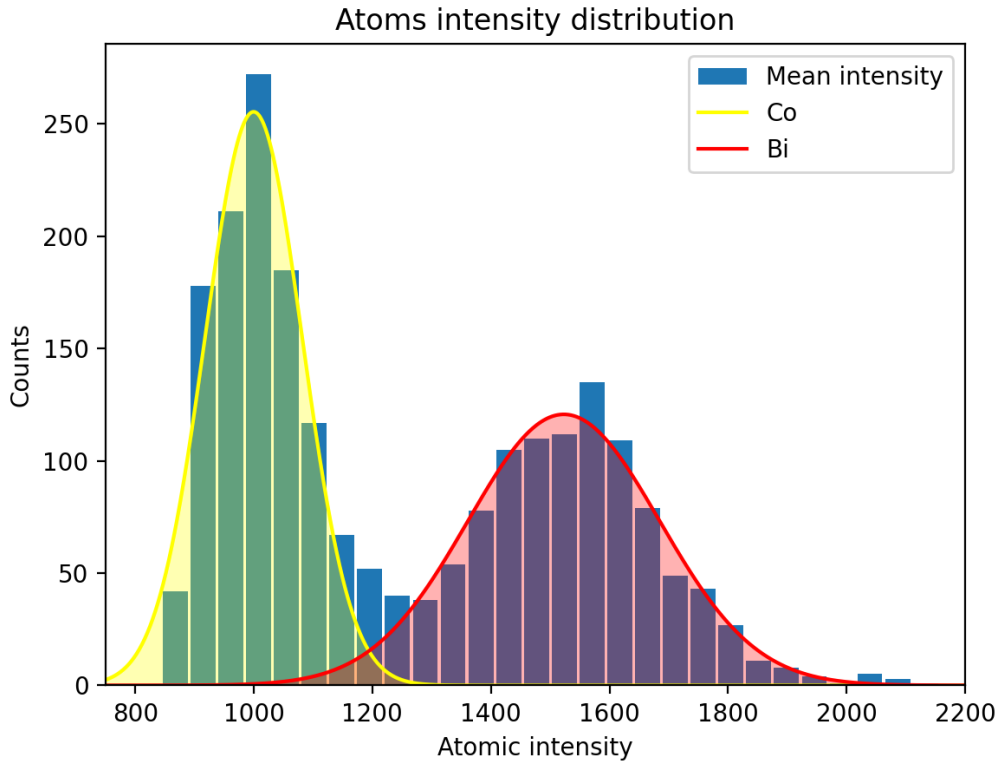
Atomic-Scale Structural Identification







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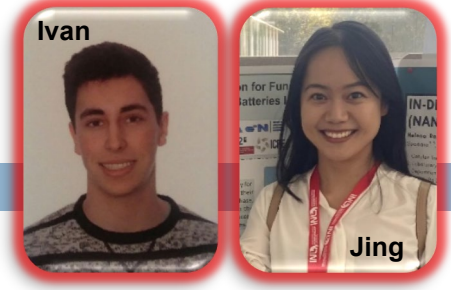
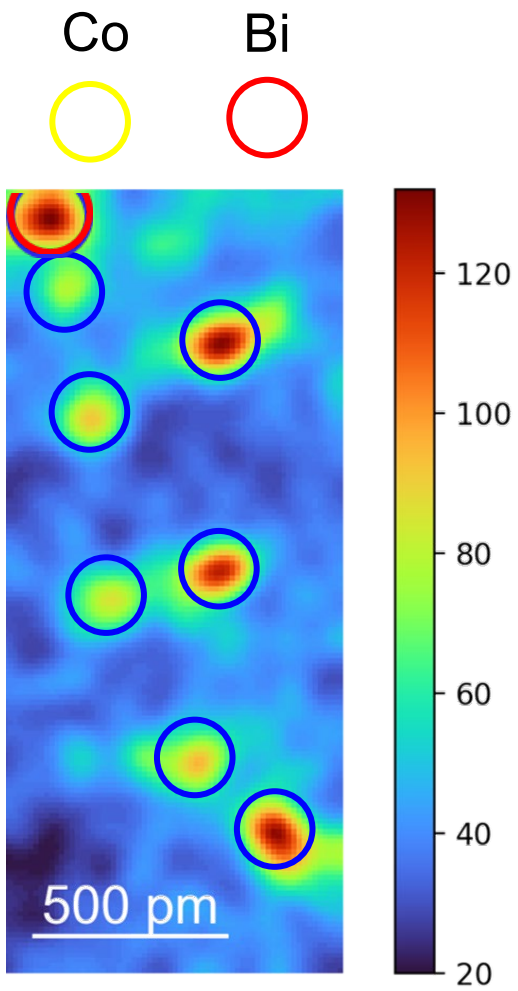
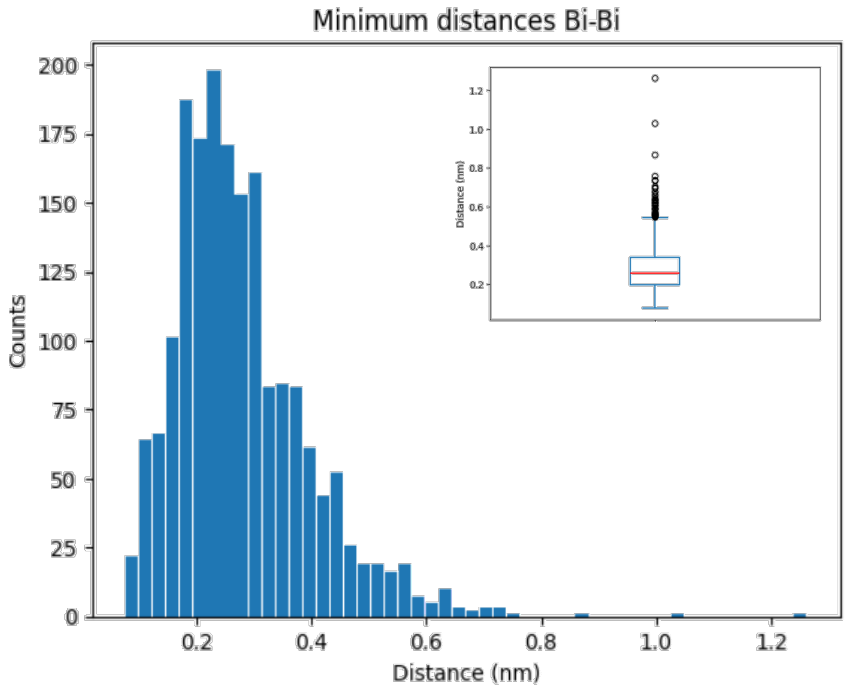
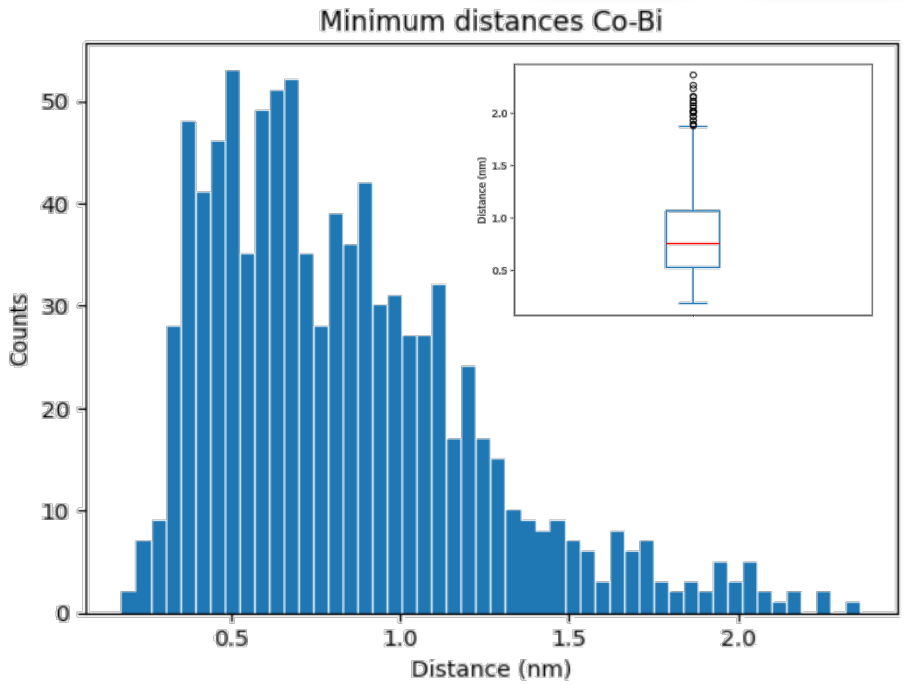
Atomic-Scale Structural Identification









Histograms of the minimum distance's distribution from Co and Bi atoms within Co-Bi/CN

≈32% of the metal atoms form coupled Co–Bi pairs
≈31% were organized as either Bi–Bi or Co–Co pairs
≈37% existed as isolated Co or Bi atoms.

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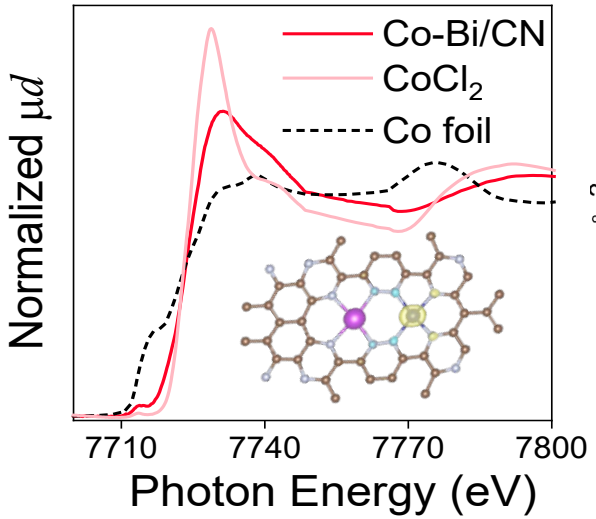
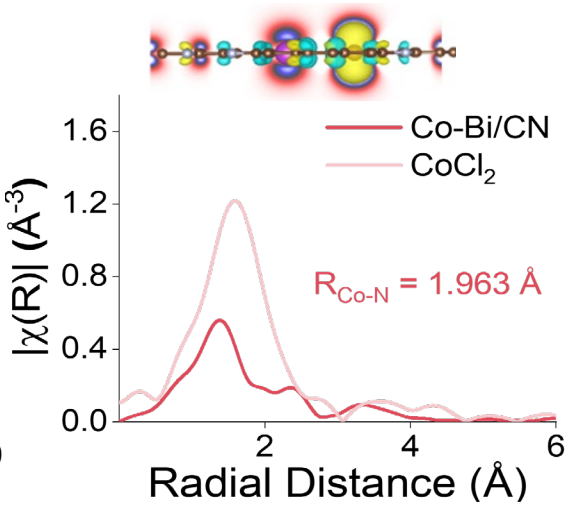
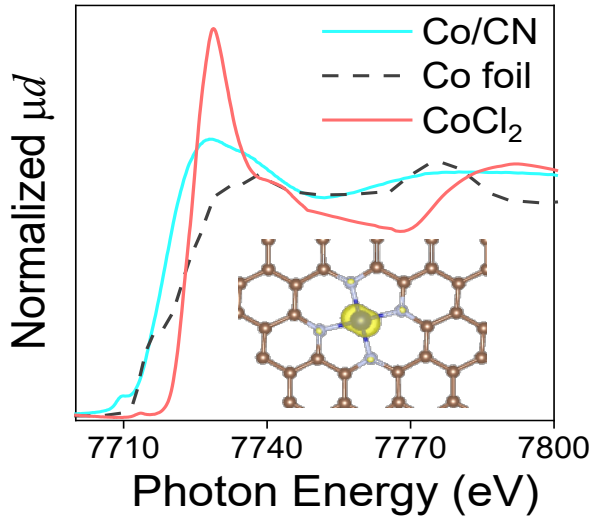
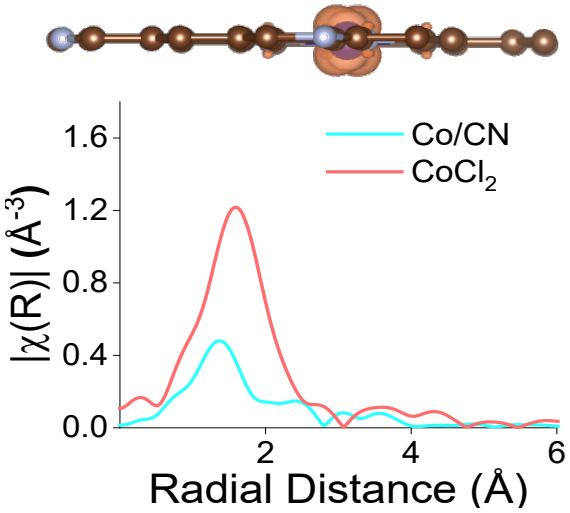
Atomic-Scale Structural Identification

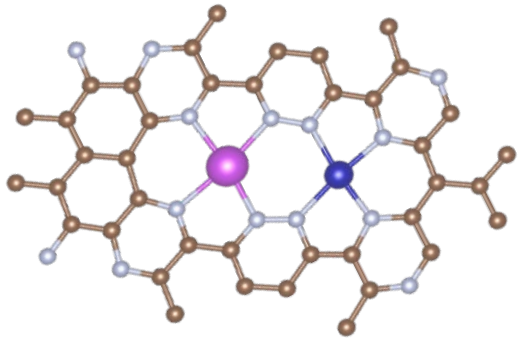
TM K-edge XANES spectra (left) and FT of the EXAF spectra (right)











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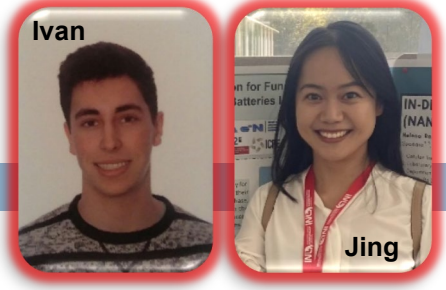
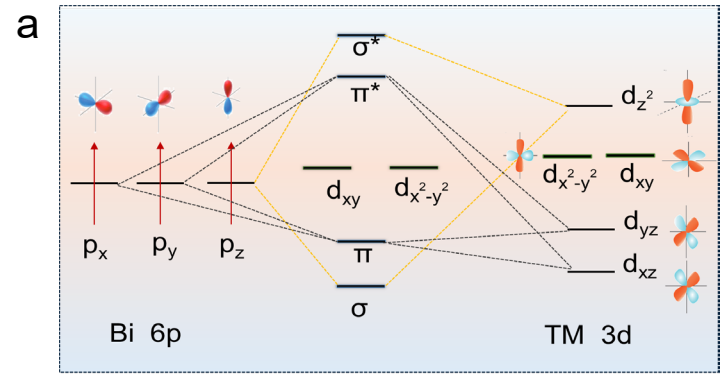
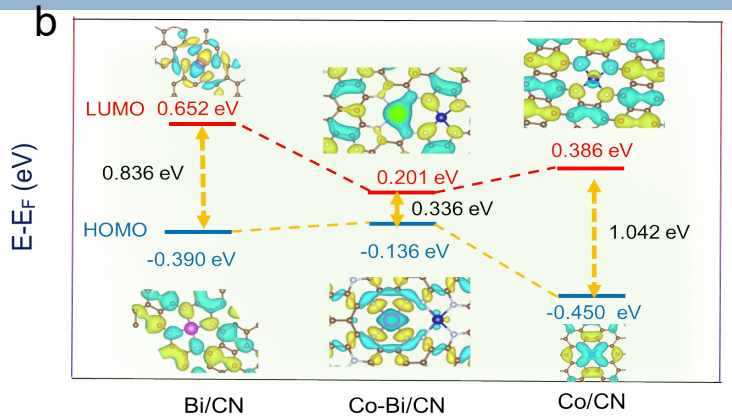
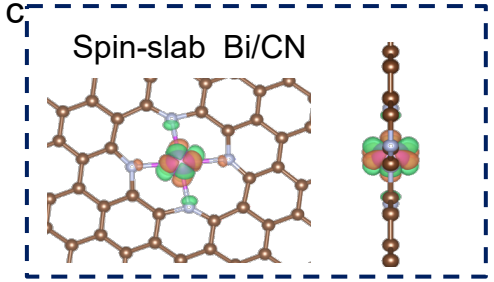
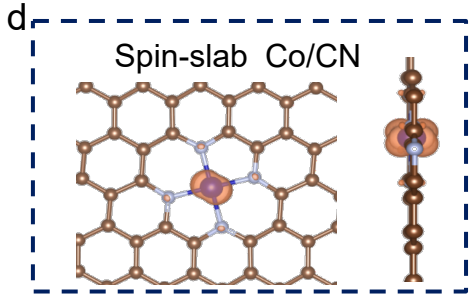
Mechanistic Insights: Synergistic Catalysis

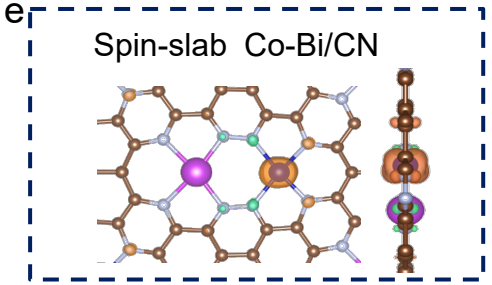


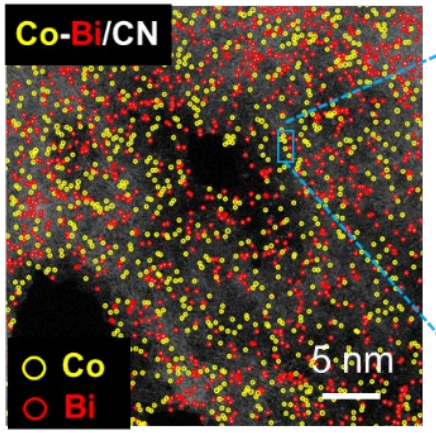


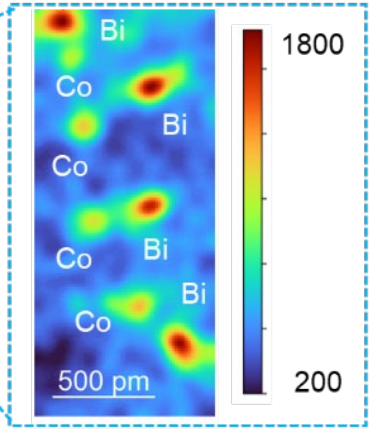


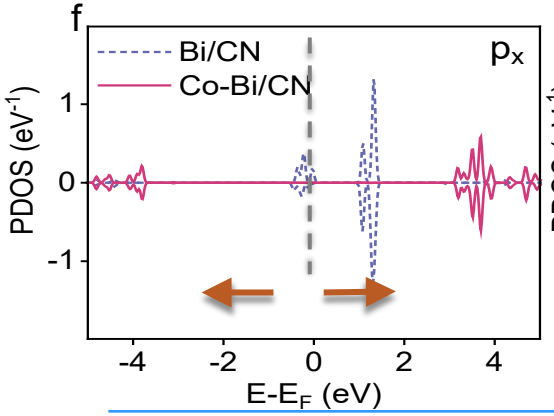


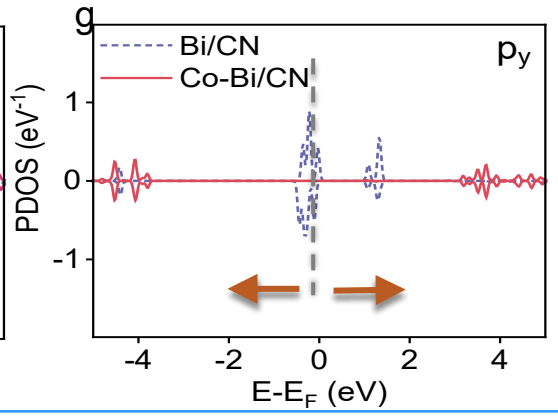


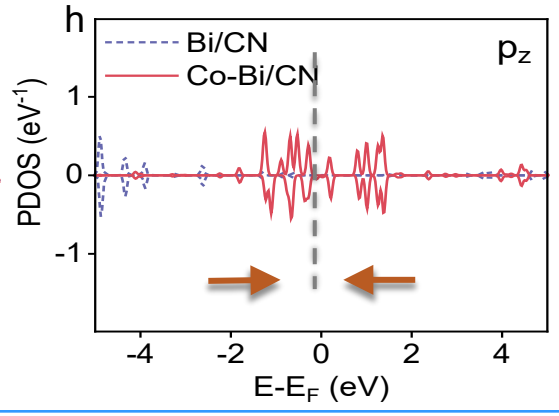








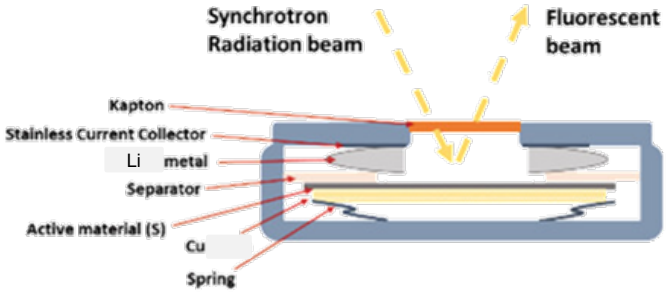


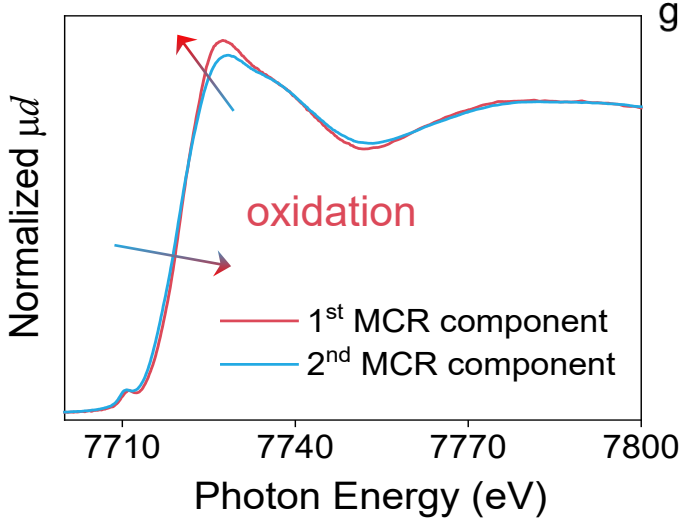


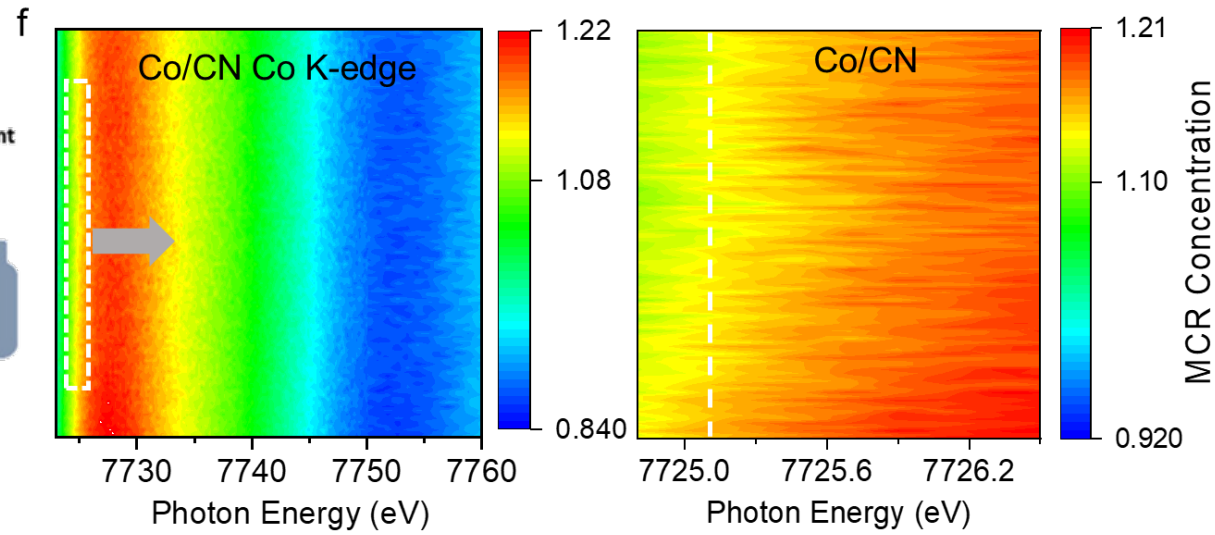
32% coupled Co-Bi pairs
31% either Bi-Bi or Co-Co pairs
37% existed as isolated Co or Bi atoms

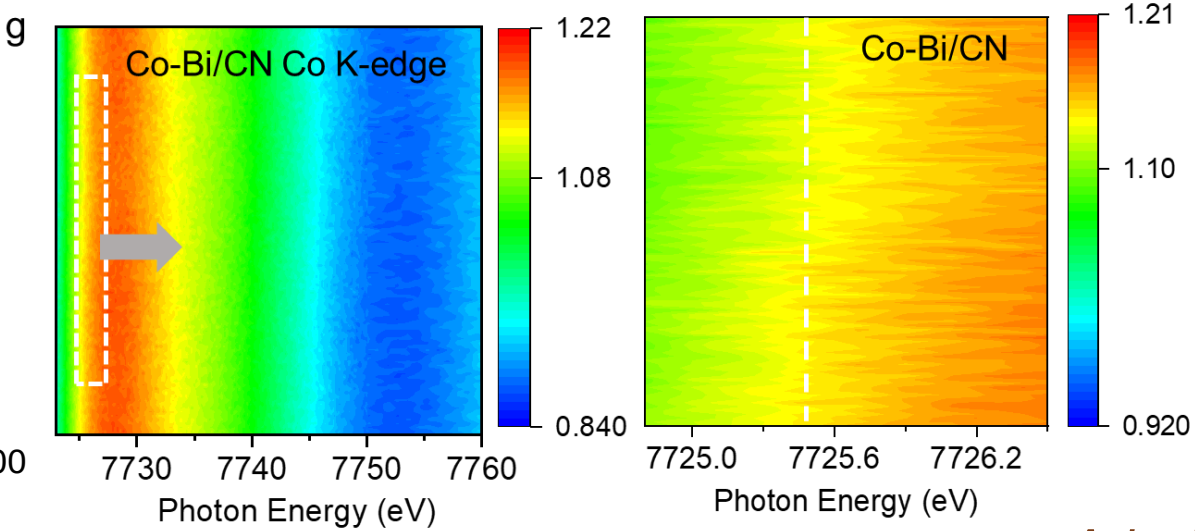
Adv. Mater., **38**, e11345 (2026)

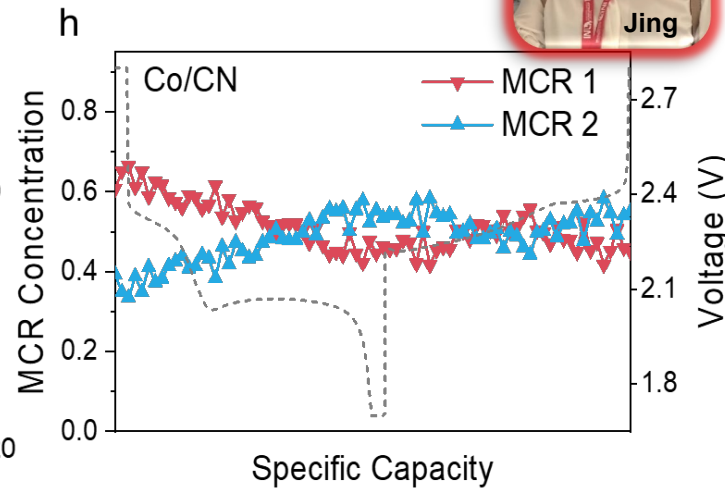
Mechanistic Insights: Synergistic Catalysis

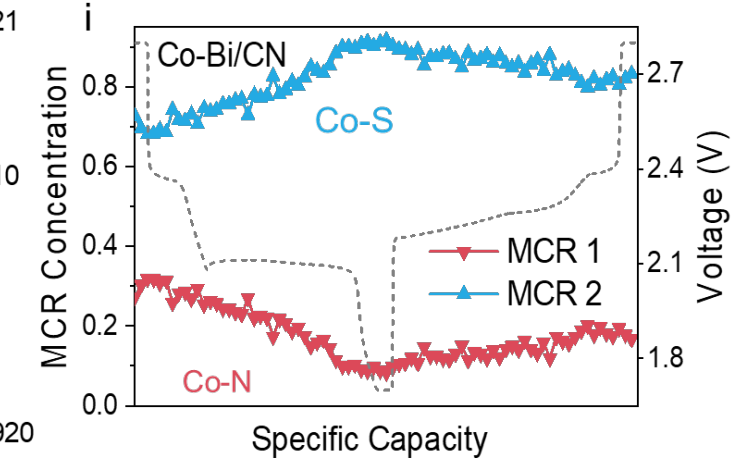












Adv. Mater., **38**, e11345 (2026)

XEELS combined with XAS- XANES

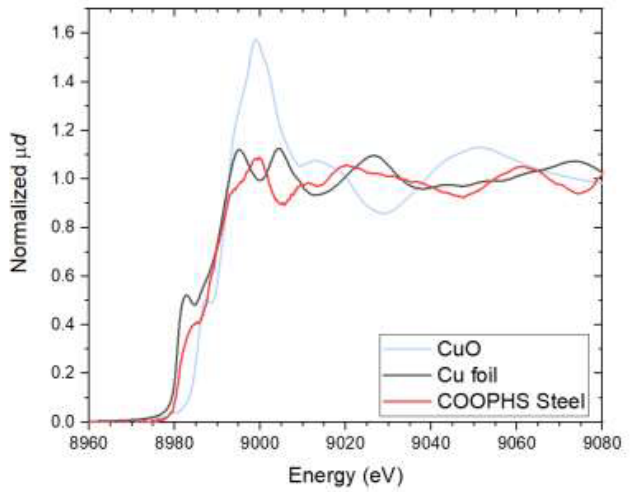


Figure 1. XANES Cu K-edge spectra of Cu agglomerations in 22MnB5 steel, shown alongside CuO and Cu foil standards for comparison. Taken from Kino's report on WP5

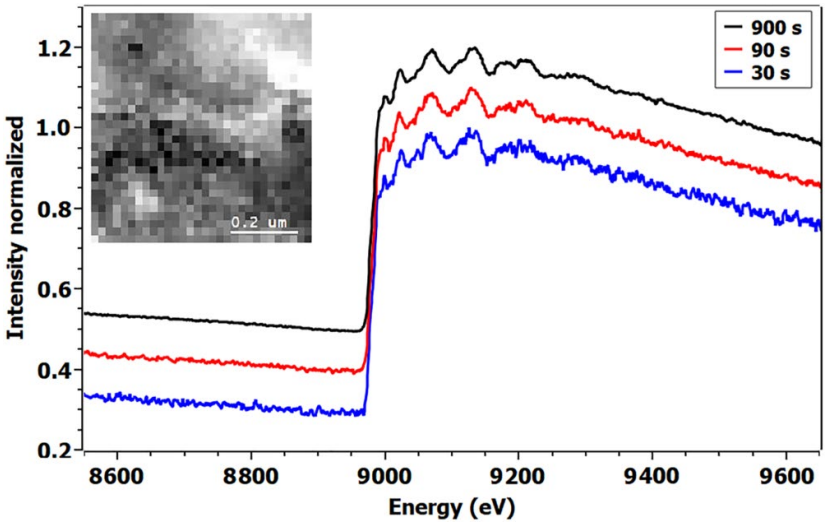


Figure 2. Inset: 30×30 spectrum image (SI) scan map of metallic Cu. XEELS spectra at the Cu K-edge

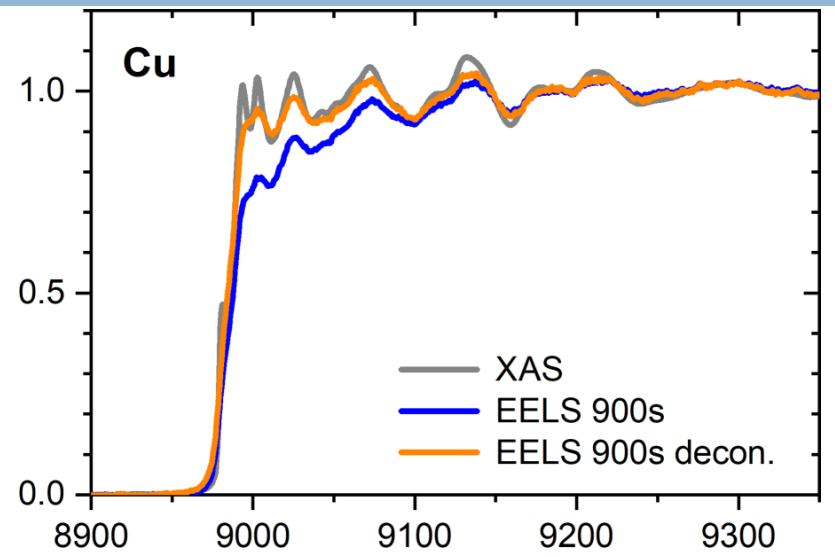
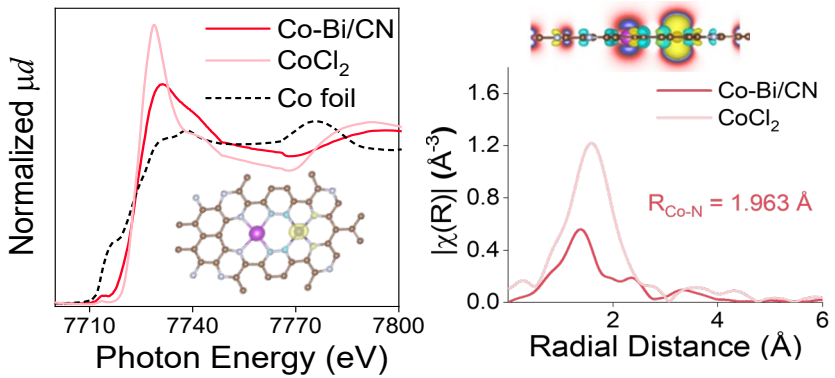


Figure 3. EELS (900 s, without and with low-loss deconvolution) and the XAS data measured for metallic Cu at the Cu K-edge after background subtraction, normalization, and flattening (DESY).



Adv. Mater., **38**, e11345 (2026)

DOI: 10.1103/PhysRevApplied.23.054095

*Combine with EXAFS + XEELS simulations

Atomic-Scale Structural Identification

1+1>2!

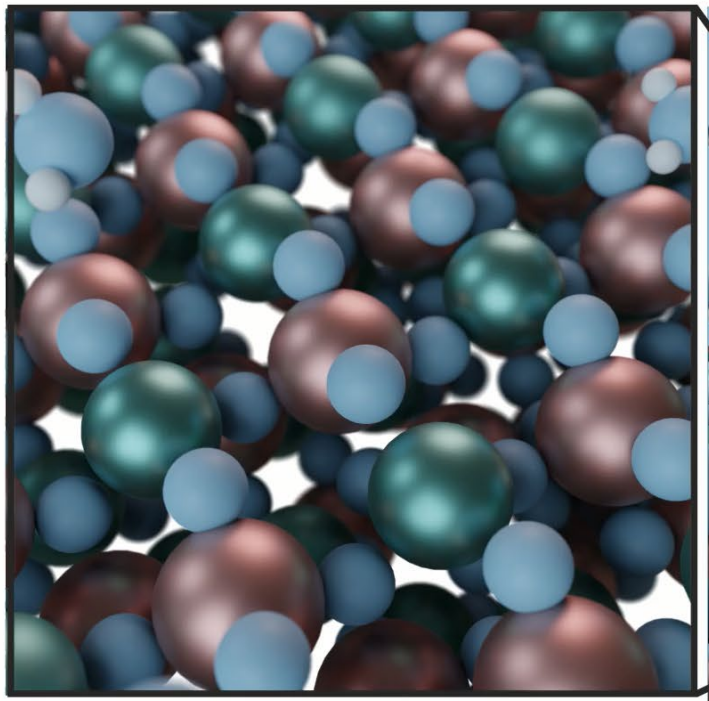
- **Superior Catalysts Identified:** Among the synthesized TM–Bi/CN dual-atom catalysts, **Co–Bi/CN/S and Ni–Bi/CN/S** exhibit the fastest sulfur redox kinetics, highest first discharge plateau, balanced Q_2/Q_1 ratios, and excellent rate performance.
- **Limiting Factors Clarified: Mn–Bi/CN/S, Co/CN/S, and Bi/CN/S** show inefficient $S_8 \rightarrow Li_2S_8$ conversion, premature Li_2S_2 formation, and extended Li_2S nucleation times, which lead to active material loss, poor rate capability, and reduced cycling stability.
- **Mechanistic Insights Provided:** DFT calculations reveal that the **asymmetric Co–Bi coordination** enhances local electron density, strengthens Co–S interactions, and improves electron transfer, thereby boosting the catalytic activity of Co–Bi/CN.
- **Design Principles Established:** The combined electrochemical and theoretical results establish a **rational platform for designing optimized dual-atom catalysts**, with strong implications for high-performance Li–S cathodes and other conversion-type electrocatalytic systems.

Adv. Mater., **38**, e11345 (2026)

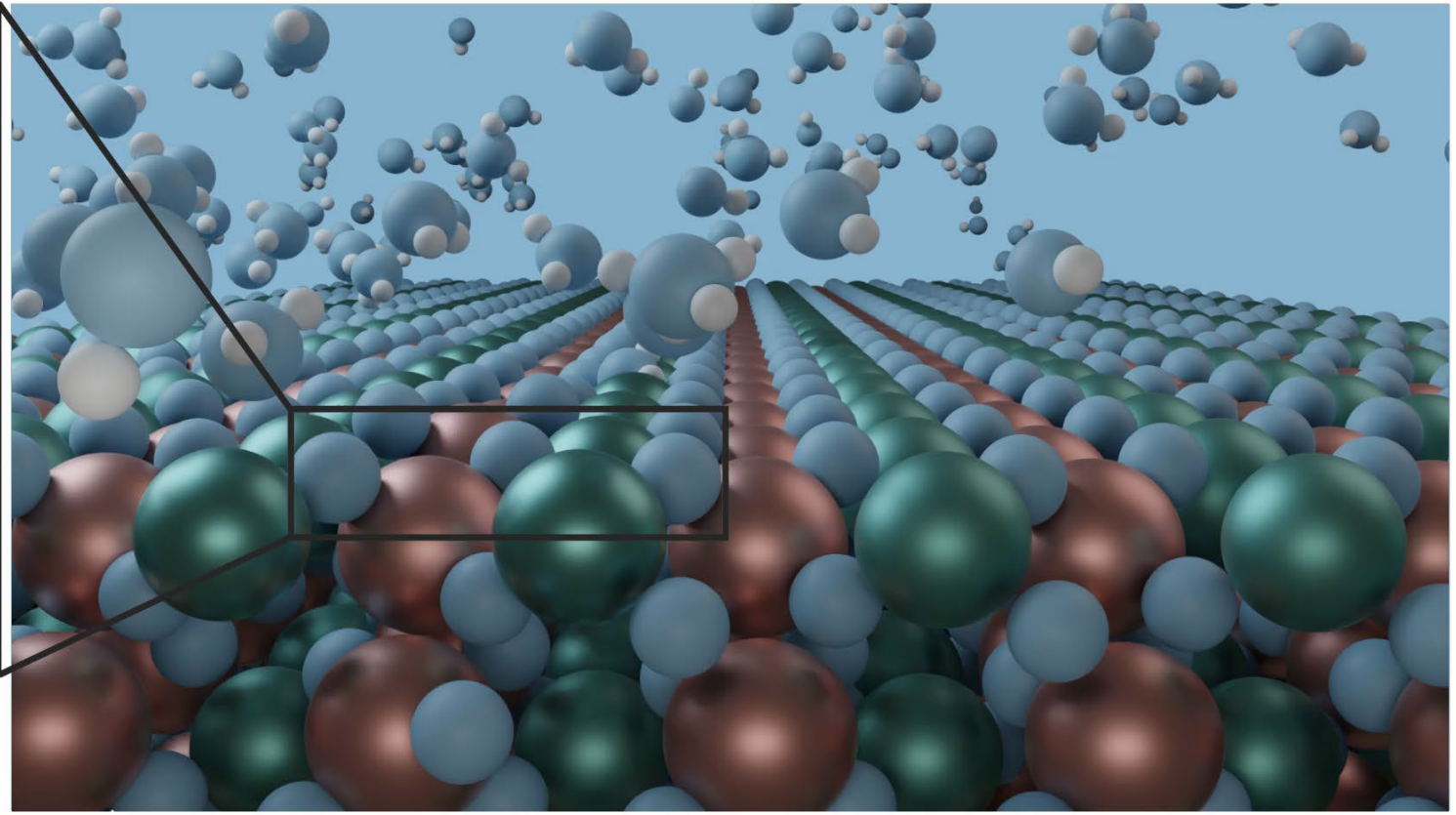
Activation of CoWO4 for OER

Delamination process

The activation mechanism involves introducing **high-valence sacrificial elements** like W that during activation, a **water/hydroxide – WO_4^{2-} anion exchange process** creates a defective lattice that can trap hydroxide and water species



Closeup of a WO_4 molecule leaving the top layer.

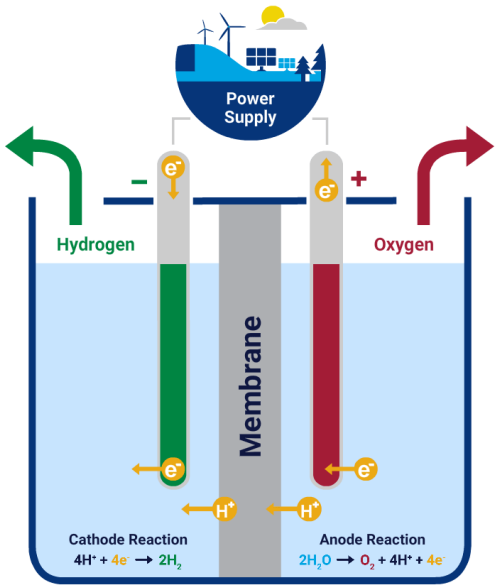


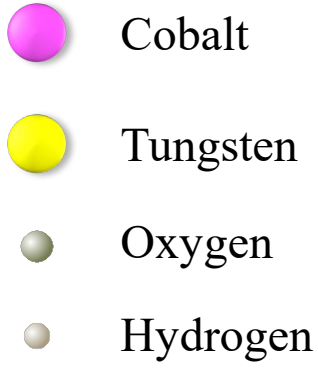
Conceptualization of the side view during the delamination process.

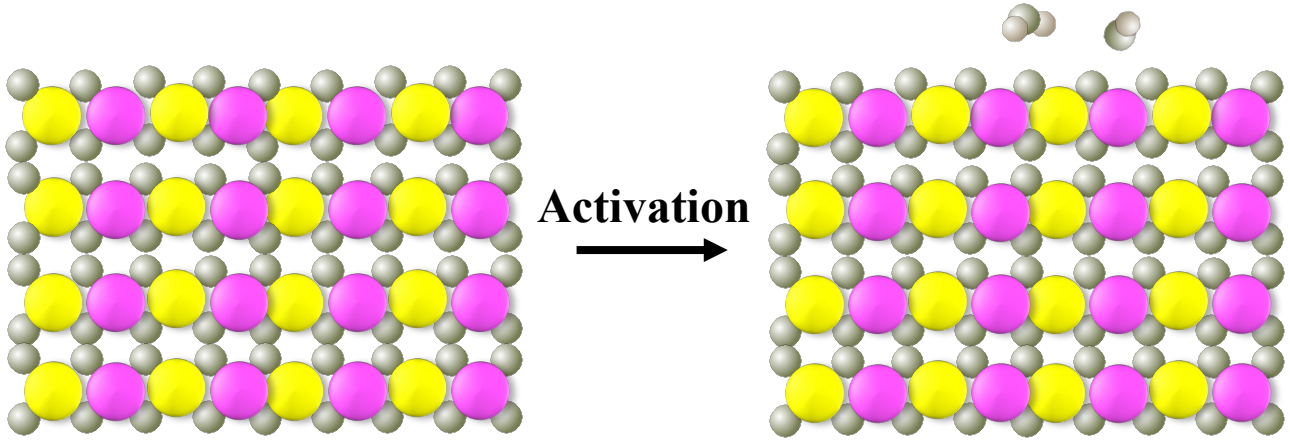
O H Co W

Science, **384**, 1373 (2024)

Activation of CoWO4 for OER

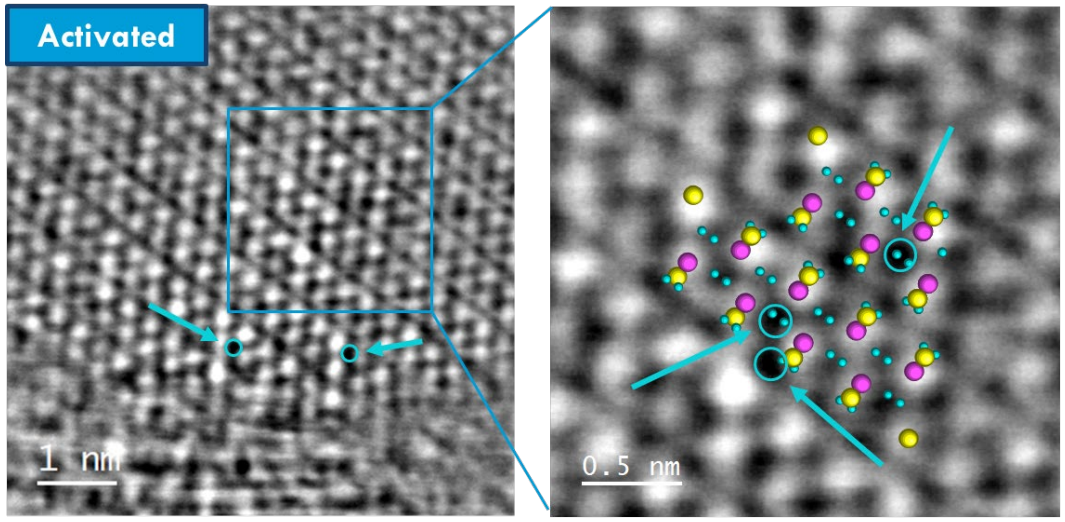






Pre-catalyst

Activated catalyst



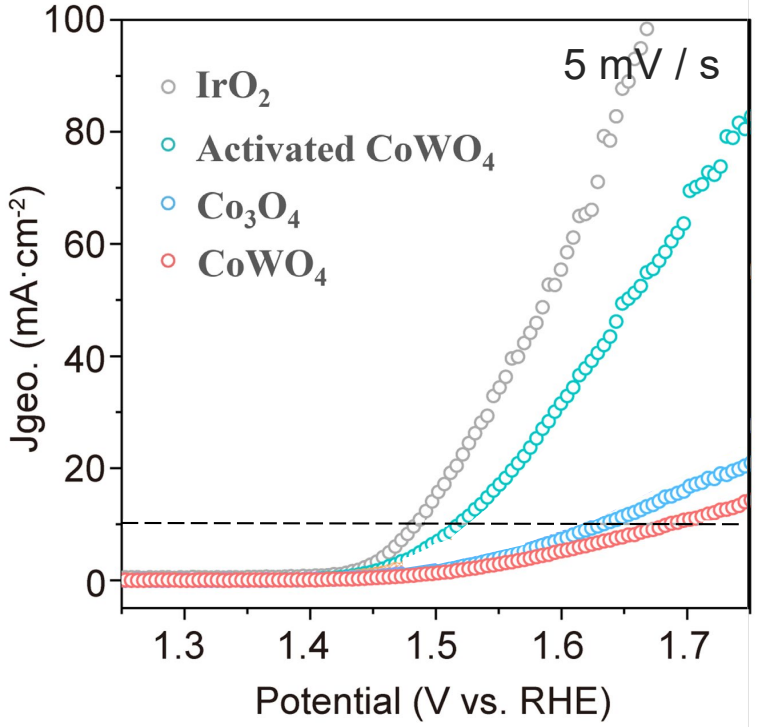
- Trapping of water and hydroxide species in the generated WO_4^{-2} vacancies
- Adsorbed-water OER mechanism enhances poor CoOx stability.
- Stable operation for >600 hour at current density of 1 A cm^{-2}

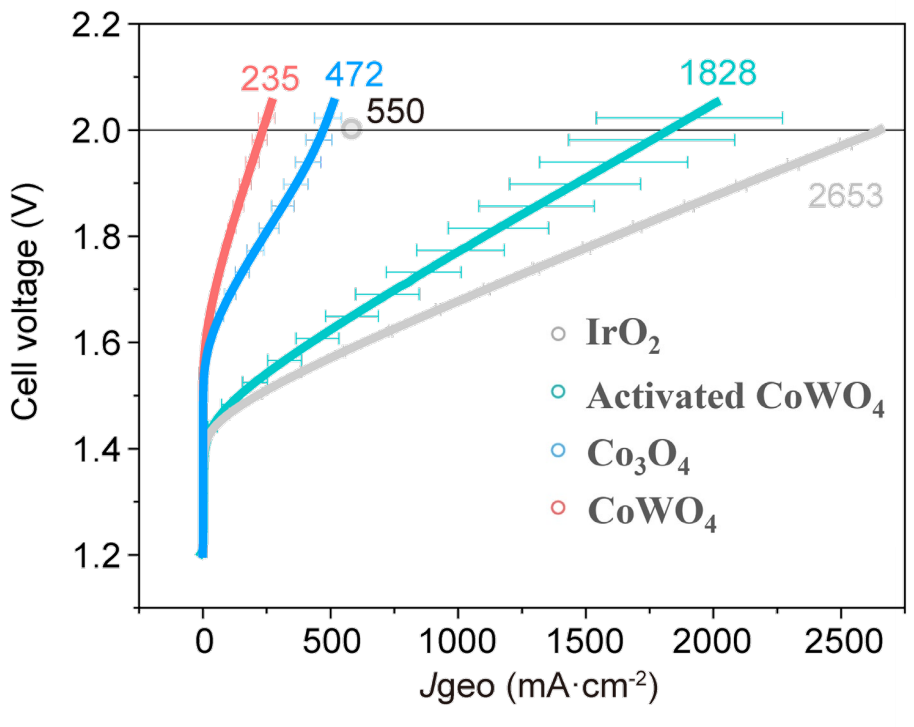
Science, **384**, 1373 (2024)

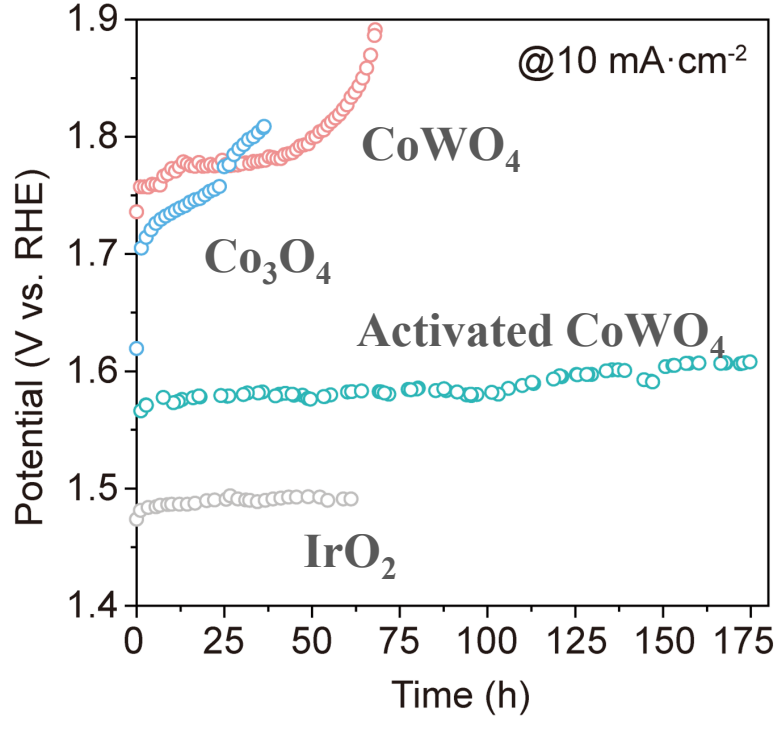
Activation of CWO4 for OER

Electrochemical performance

The activated catalyst exhibited remarkable activity and stability, close to the IrO_2 benchmark





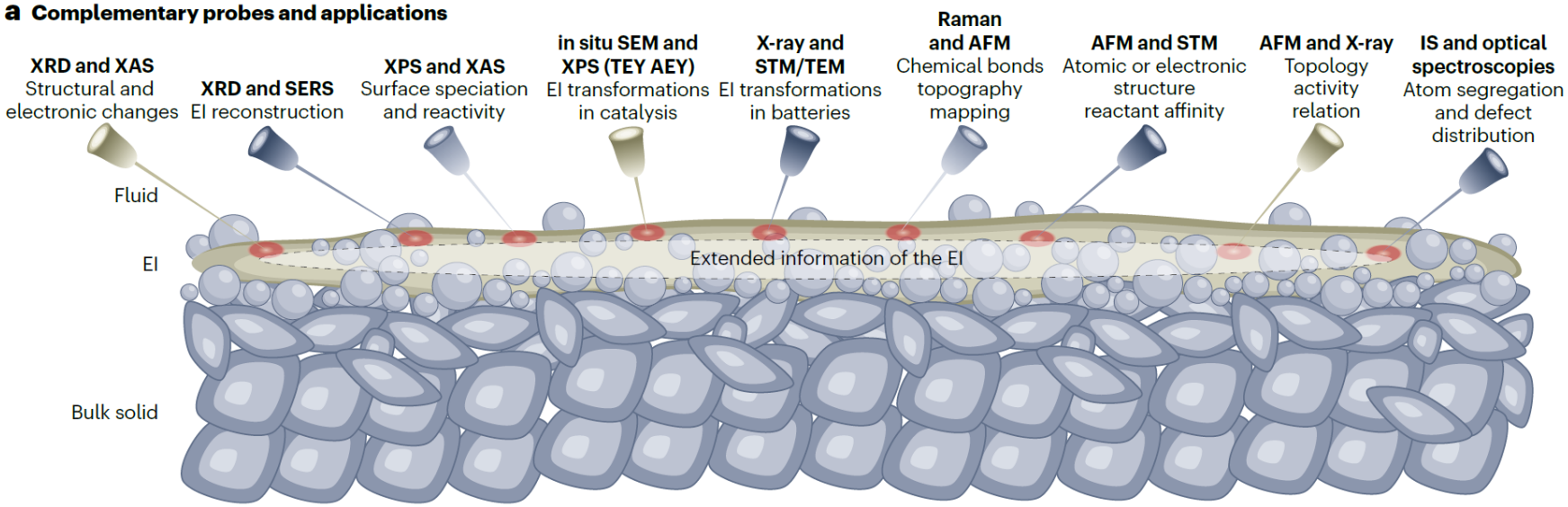


- **Stable operation for >600 hour at current density of 1 A cm^{-2}**

Science, **384**, 1373 (2024)

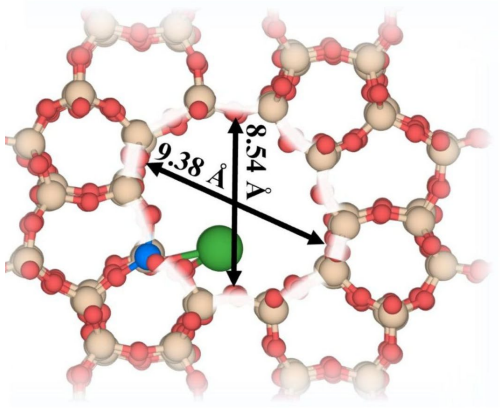
MULTIMODAL & in-Situ CHARACTERIZATION

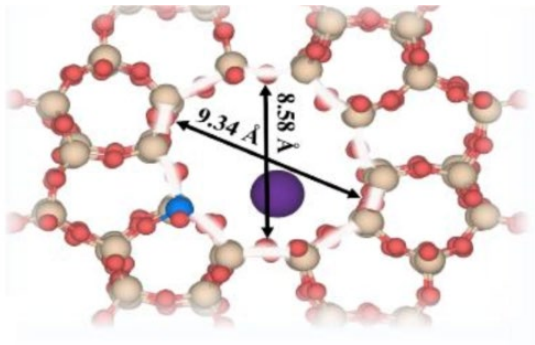
Complementary probes for the electrochemical interface.

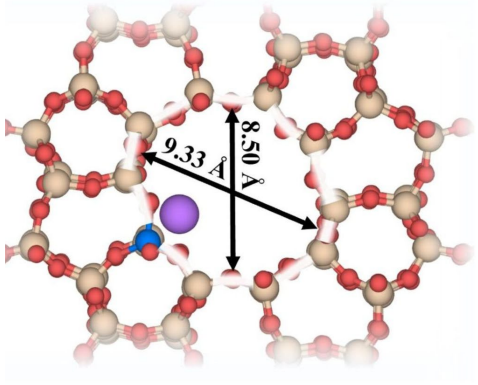


Nature Reviews Chemistry, **8**, 159 (2024)

Local Electric Field induced strain in Zeolites







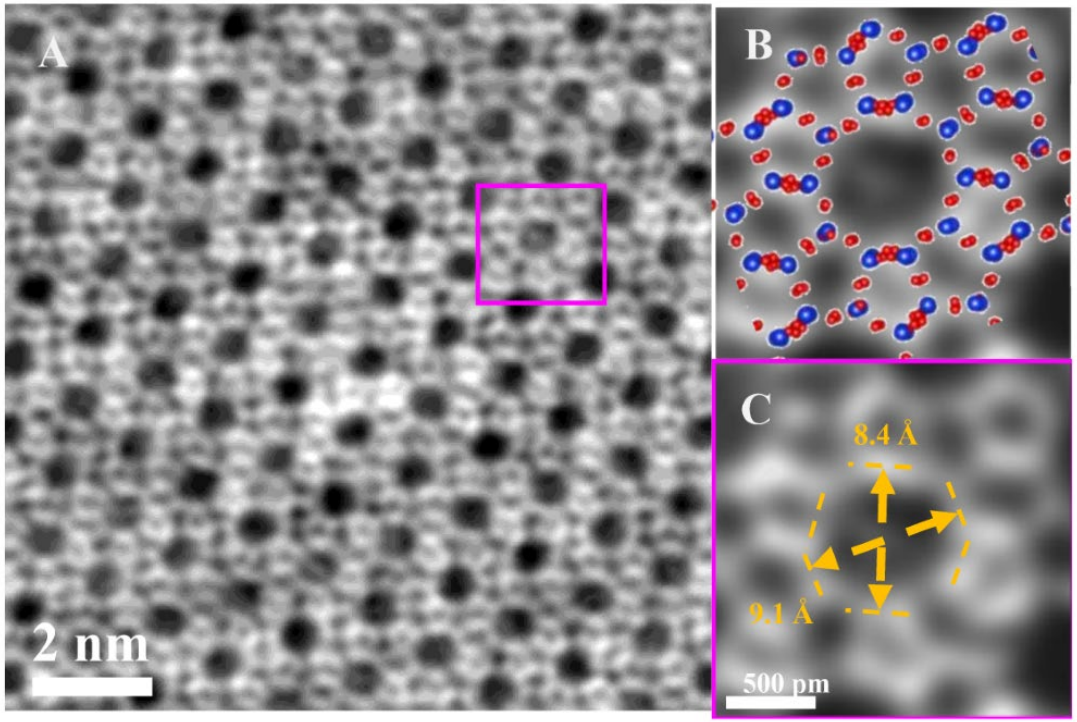
Cs^+ O

Ba^{2+} Al

Na^+ Si

Ionic radii Na^+ : 0.99 Å
Ionic radii Ba^{2+}: 1.35 Å
Ionic radii Cs^+ : 1.88 Å

DFT calculation of ring flexibility in ion-exchanged ZSM-5 (MFI type) zeolites for Na^+, Cs^+ and Ba^{2+} ions in 10-MRs



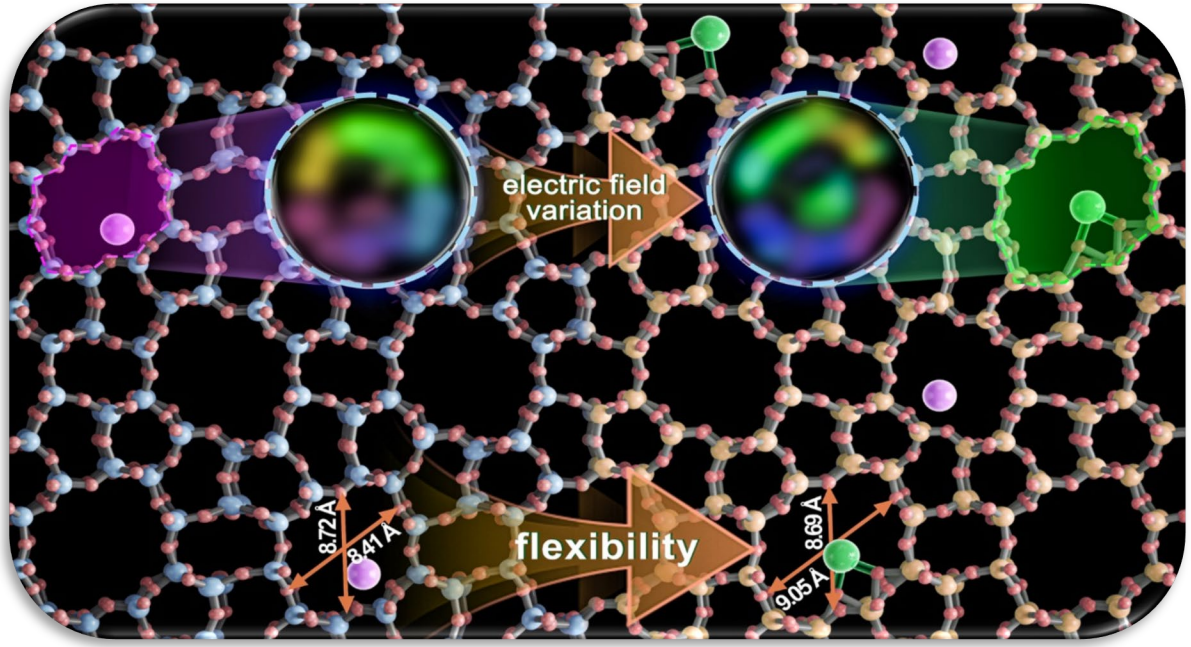
Geometric sizes:

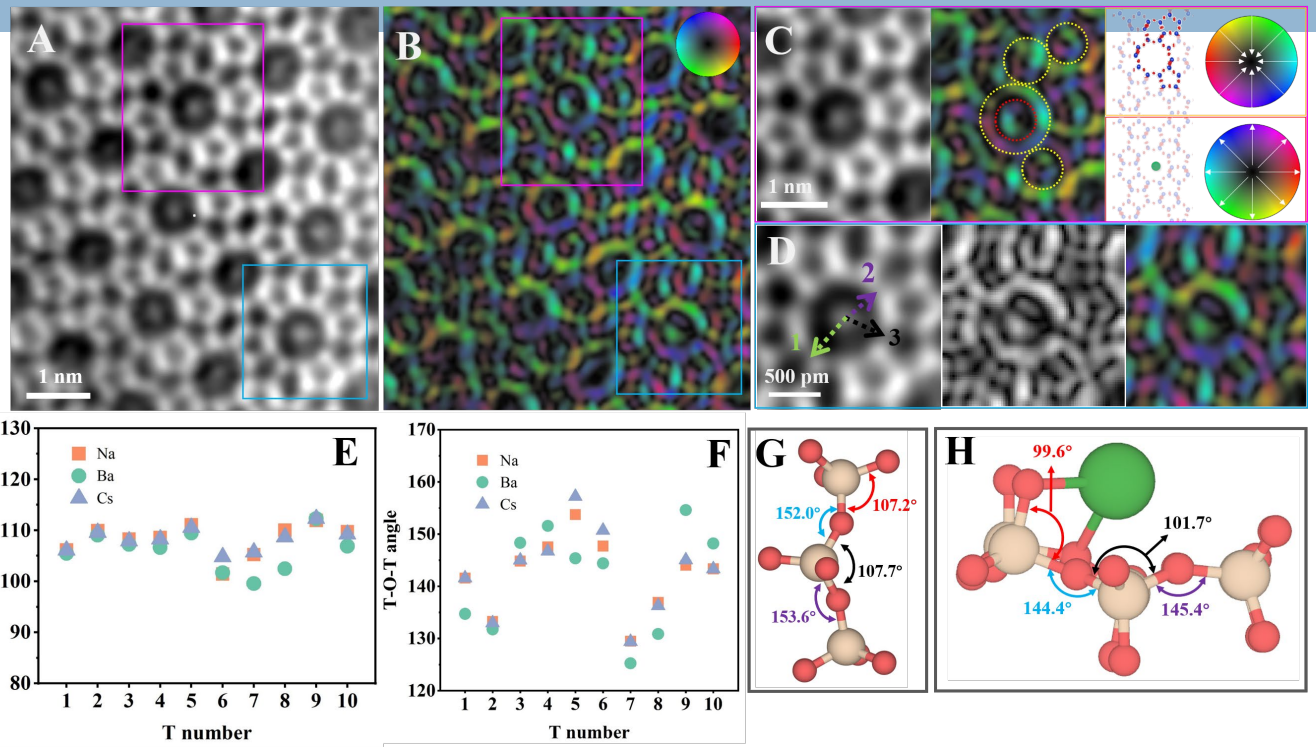
- Unoccupied 10-MRs: 8.53 Å × 8.61 Å
- Na^+-occupied 10-MRs: 9.33 Å × 8.50 Å
- Ba^{2+}-occupied 10-MRs: 9.38 Å × 8.54 Å
- Cs^+-occupied 10-MRs: 9.34 Å × 8.58 Å

Ba^{2+} ions confined within the 10-membered rings (10-MRs) trigger a 0.5 Å channel expansion, which exceeds the 0.2 Å expansion induced by Na^+ ions while maintaining the framework's macroscopic rigidity.

JACS, **just accepted**, (2026)

Local Electric Field induced strain in Zeolites





Ionic radii Na^+ : 0.99 Å
Ionic radii Ba^{2+}: 1.35 Å
Ionic radii Cs^+ : 1.88 Å
} $Cs^+ > Ba^{2+} > Na^+$

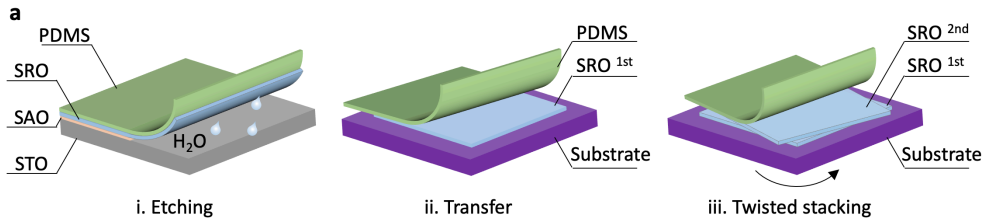
Ion-induced electric-field strength $Ba^{2+} > Cs^+ > Na^+$

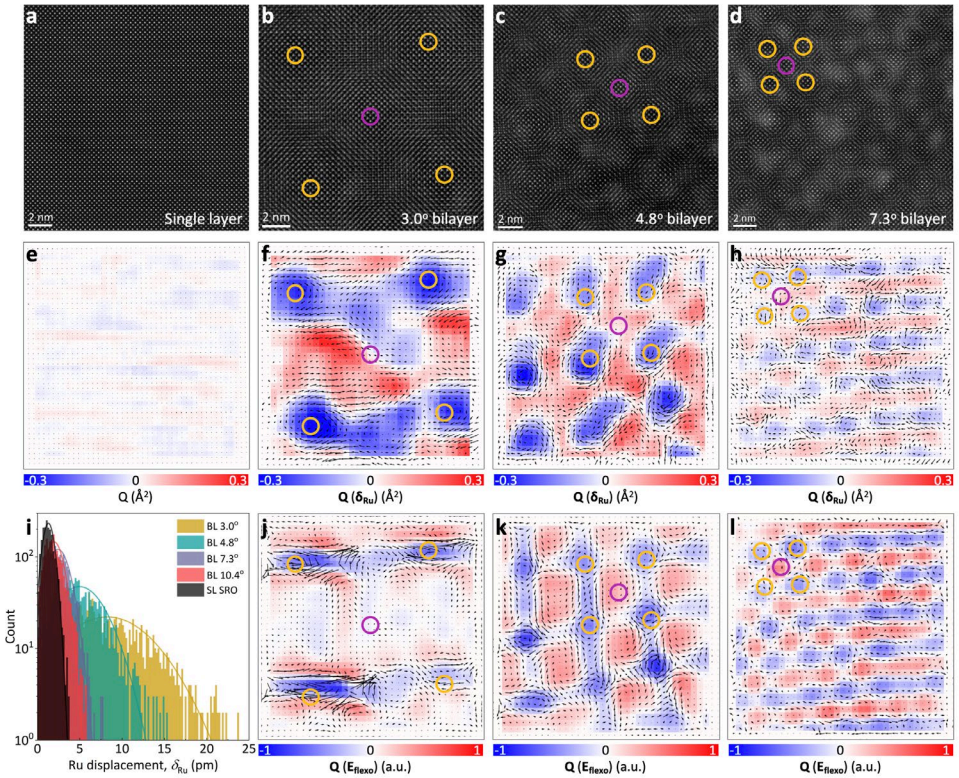
Electric field trigger mechanism for ring flexibility via DPC-STEM and DFT calculations
For Ba^{2+} ions in 10-MRs

Atomic Imaging of Ion-Triggered Flexibility and Local Electric Field Response in Zeolite Rings

JACS, **just accepted**, (2026)

4D STEM Multislice Ptychography



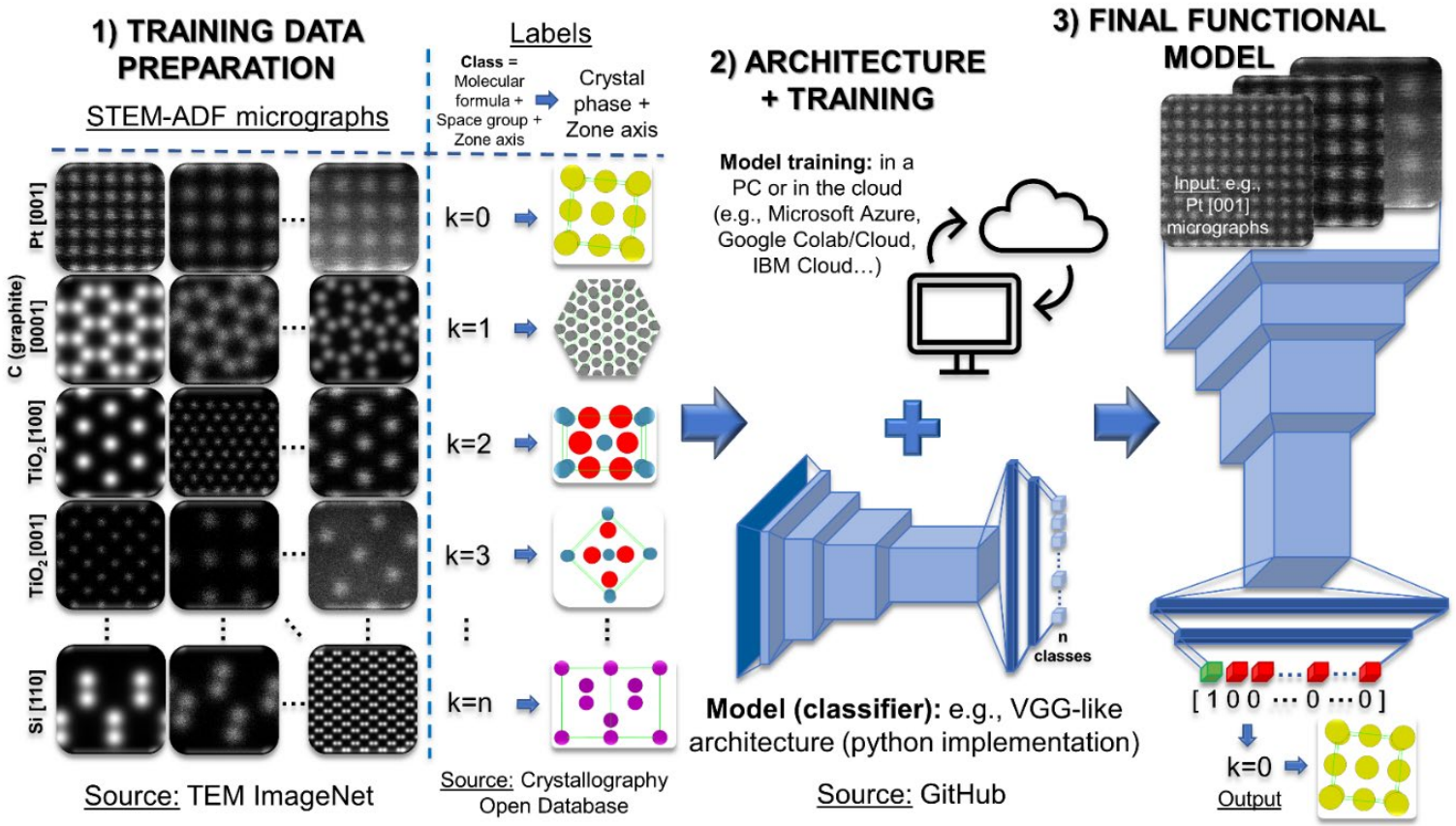


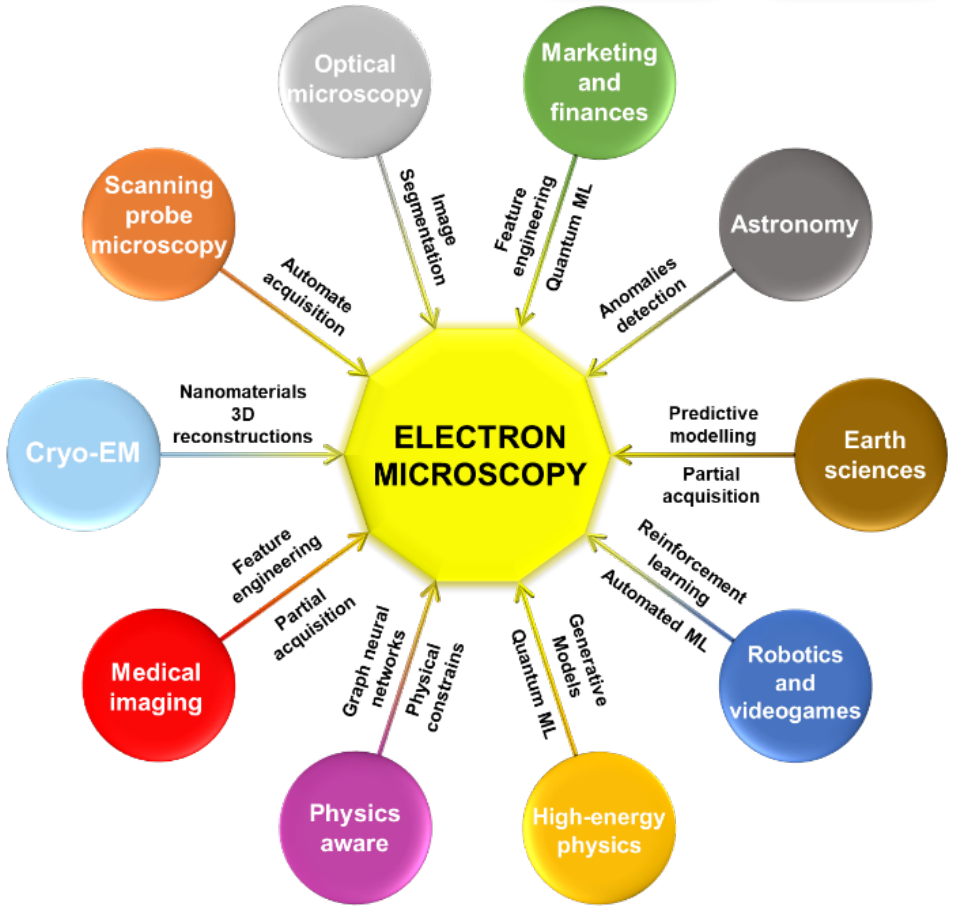
In-depth Multislice Ptychography reconstructions
Polarization Vortices in a Ferromagnetic Metal via Twistronics

Submitted, arXiv.2505.17742 (2025)

AI data analysis automation

Machine learning in electron microscopy for advanced nanocharacterization: current developments, available tools and future outlook

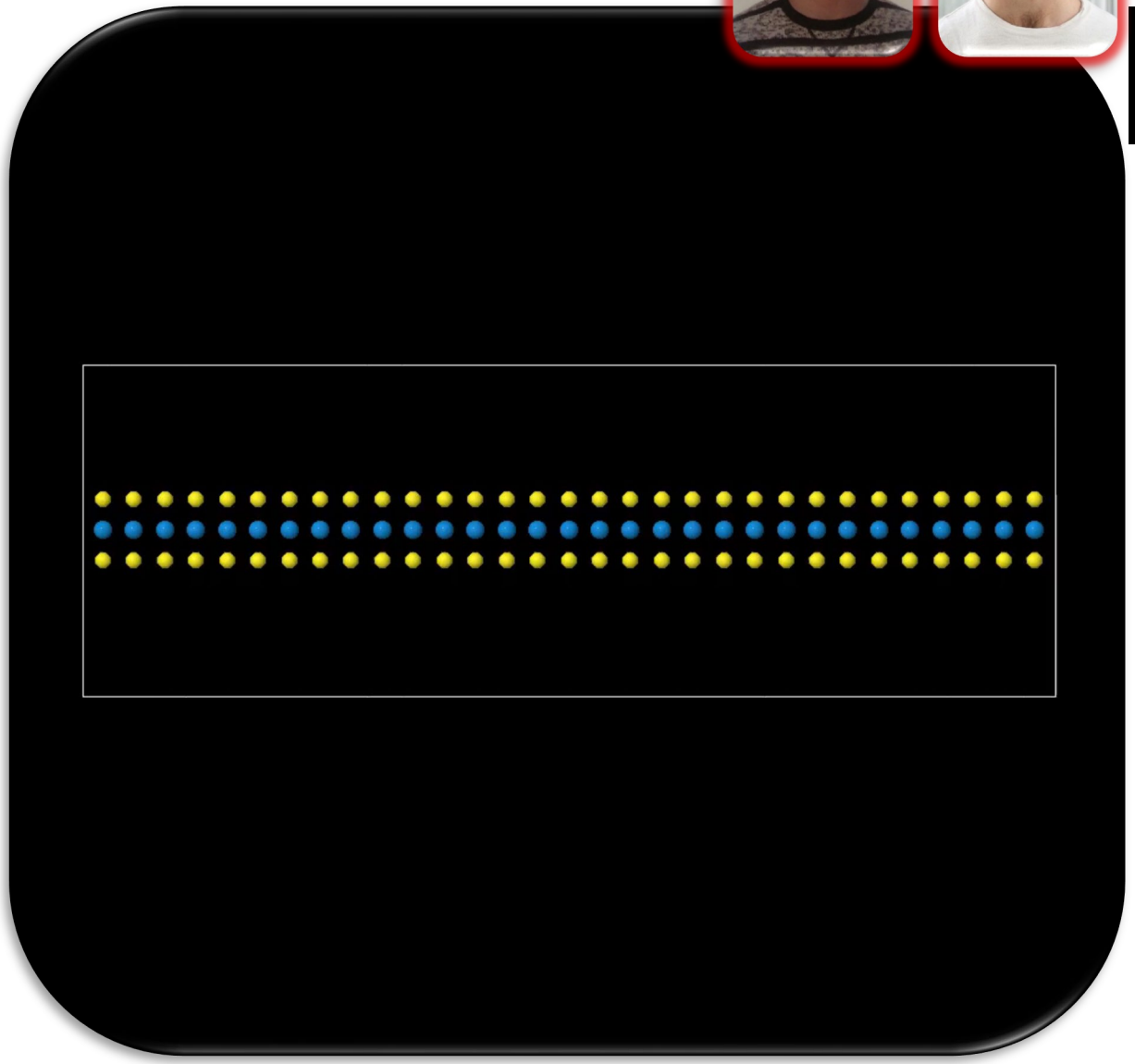




Nanoscale Horiz. **7**, 1427 (2022)

Vacancies in 2D Materials

Presence of vacancies in 2D materials might improve their physical and chemical properties:



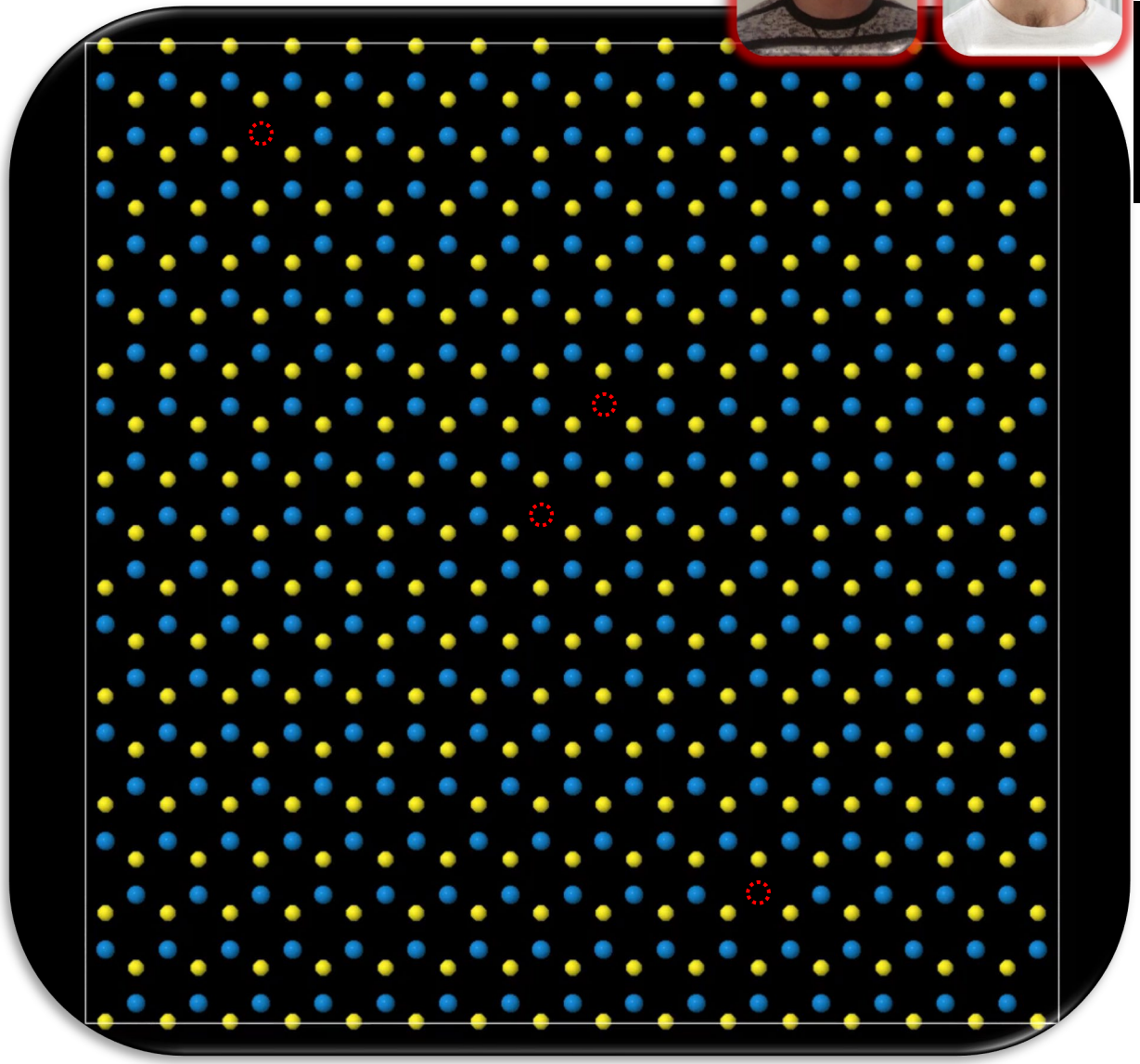
Vacancies in 2D Materials

Presence of vacancies in 2D materials might improve their physical and chemical properties:

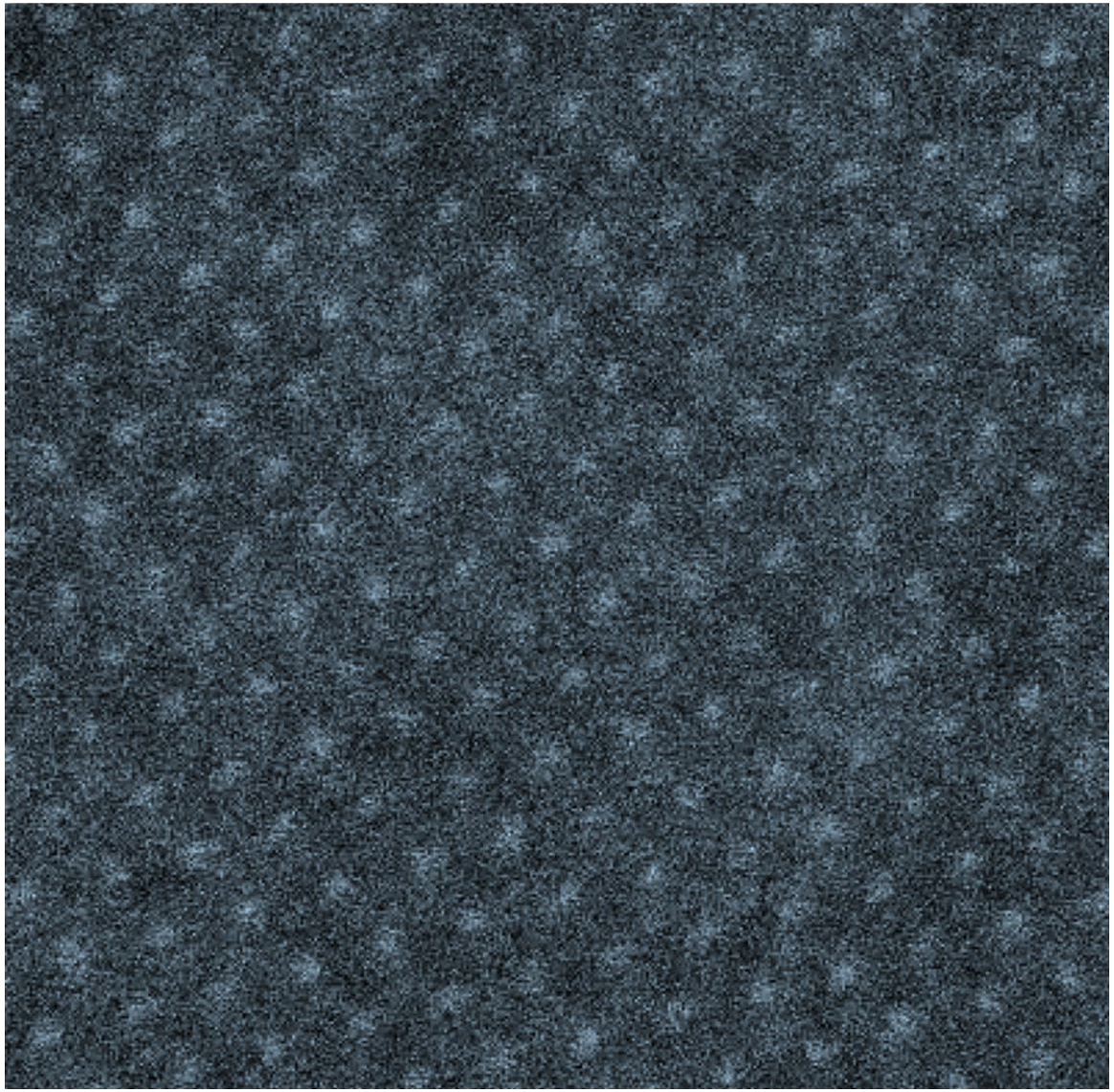
- As seen before, they can enhance the catalytic properties by modifying the local cation/metal coordination (e.g.: PtSe2).

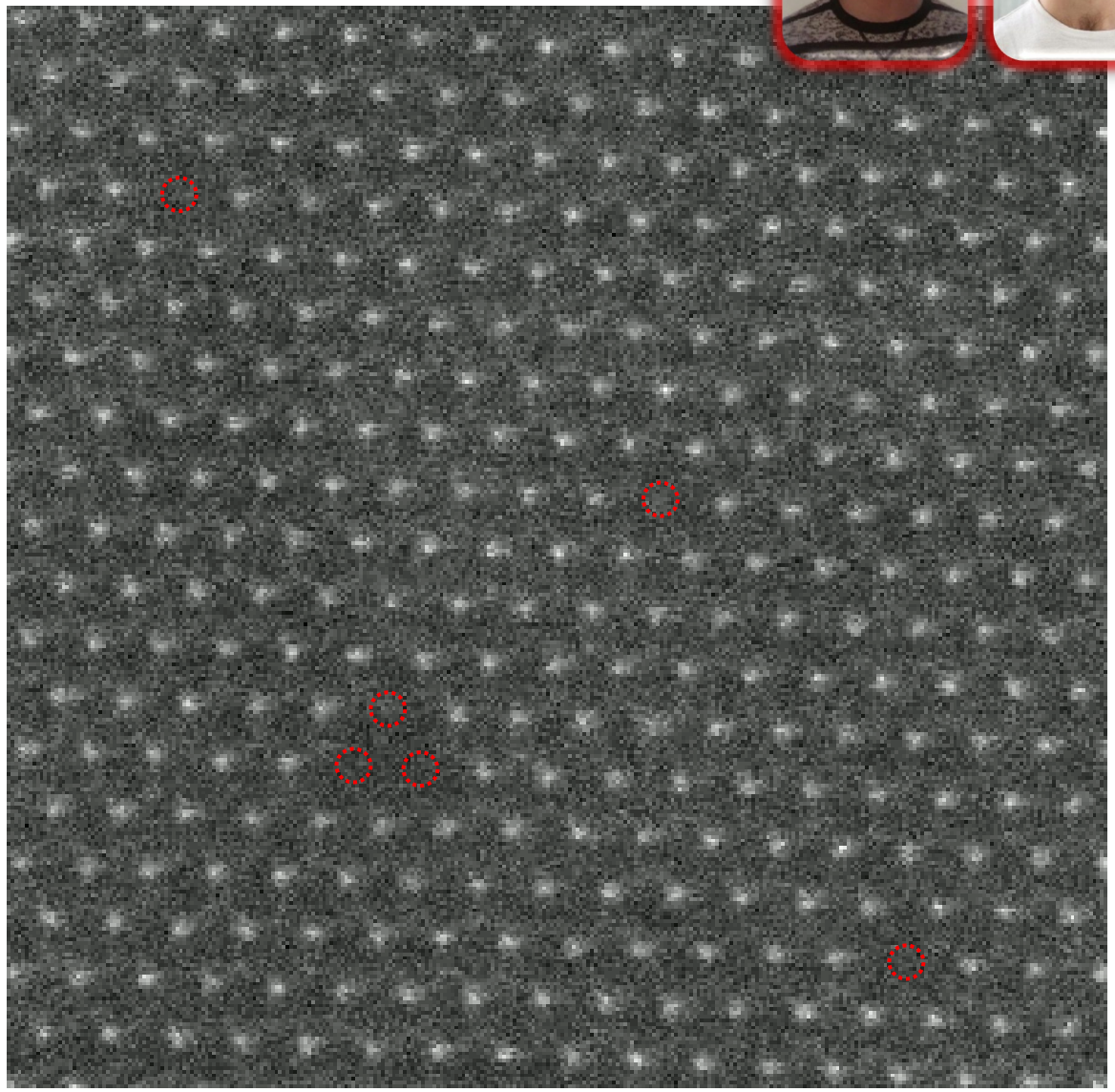
- In 2D material like hBN, MoSe2 WSe2 and WS2, might result in single-photon emission when the material is optically or electronically excited.

We have developed an automated AI methodology for detecting vacancies, an allow statistically significant studies

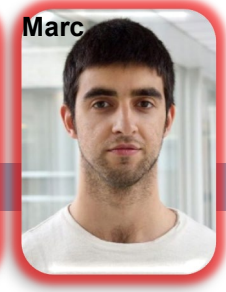


Denoising via CNN Model on FFT

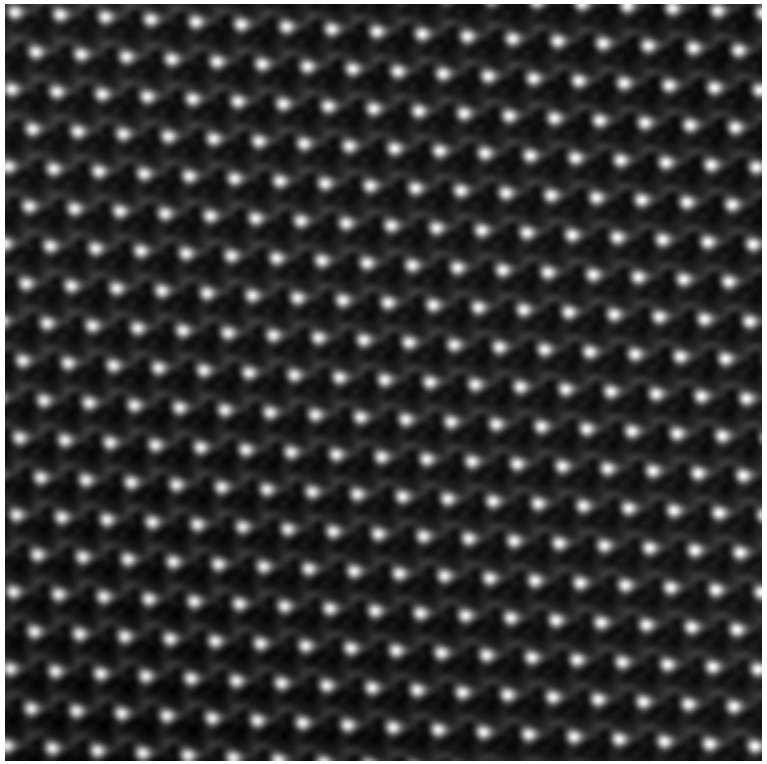




Vacancies Detection



Denoised Image



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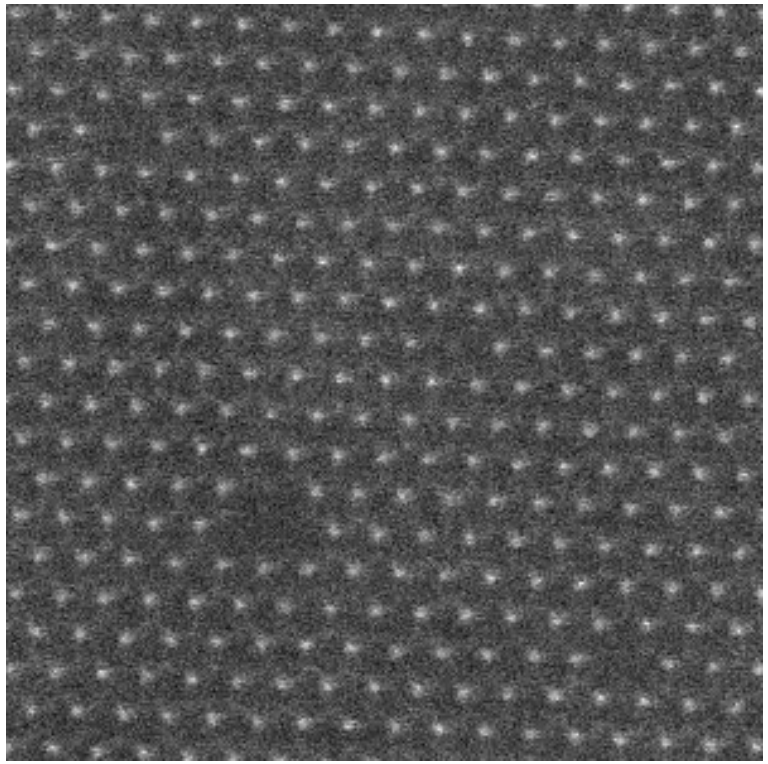
Original Image



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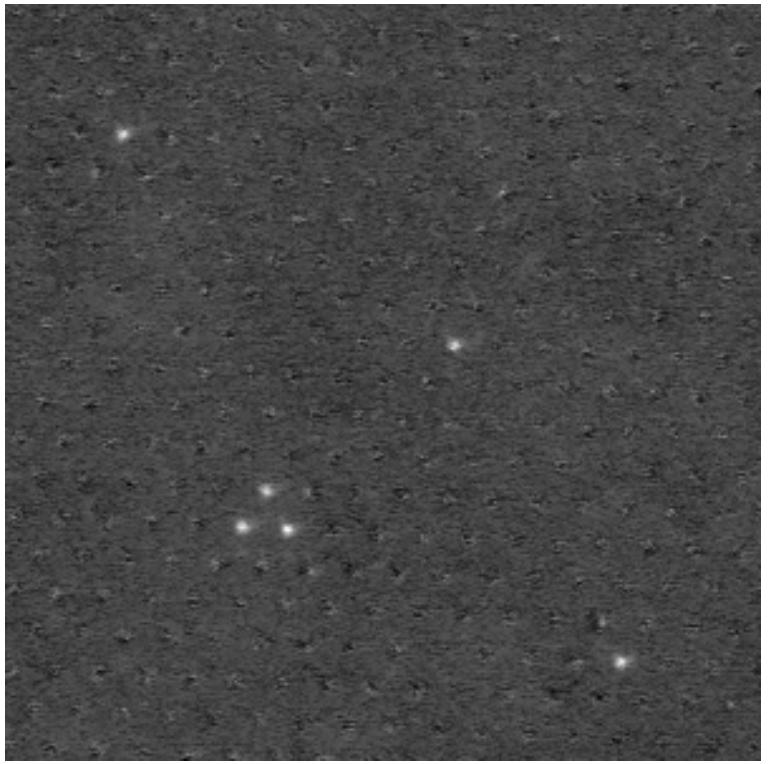
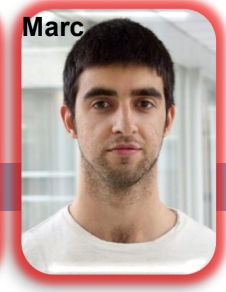
Vacancies Image



Vacancy counting: Blob Detection



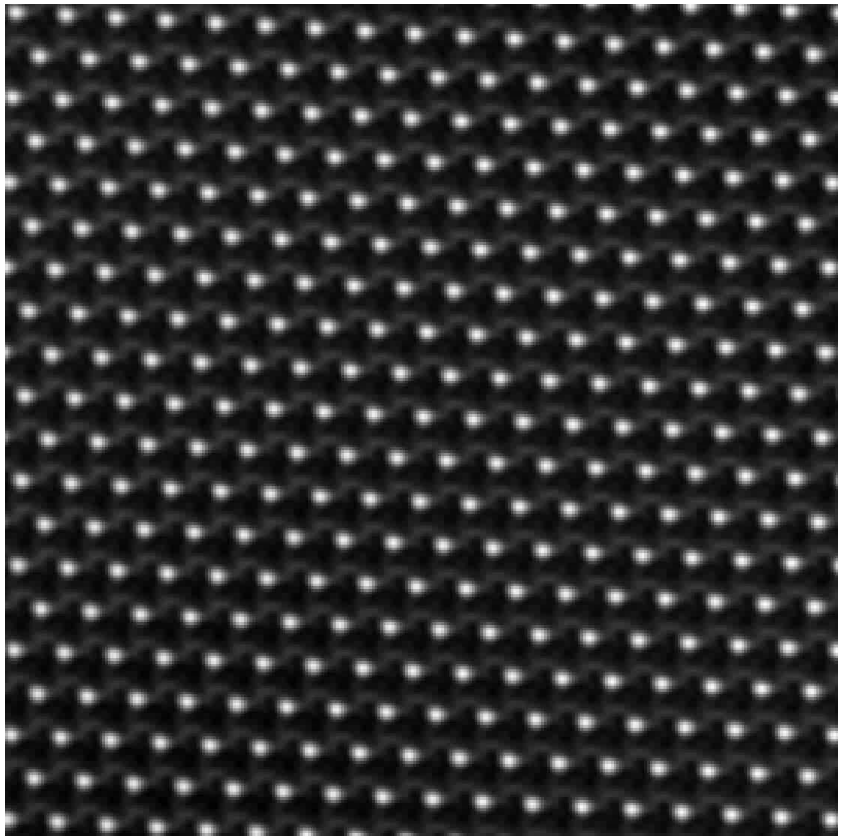
- For vacancy detection we use a **blob detection** algorithm, in particular the one known as **Laplacian of Gaussian (LoG)**.

- We **apply this algorithm for atom detection** in the **denoised image**. With this complementary result **we can also provide the percentage of vacancies** in our sample.

Vacancies Image

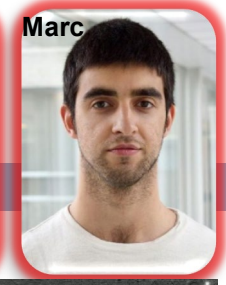
6 vacancies (2 %)

Denoised Image

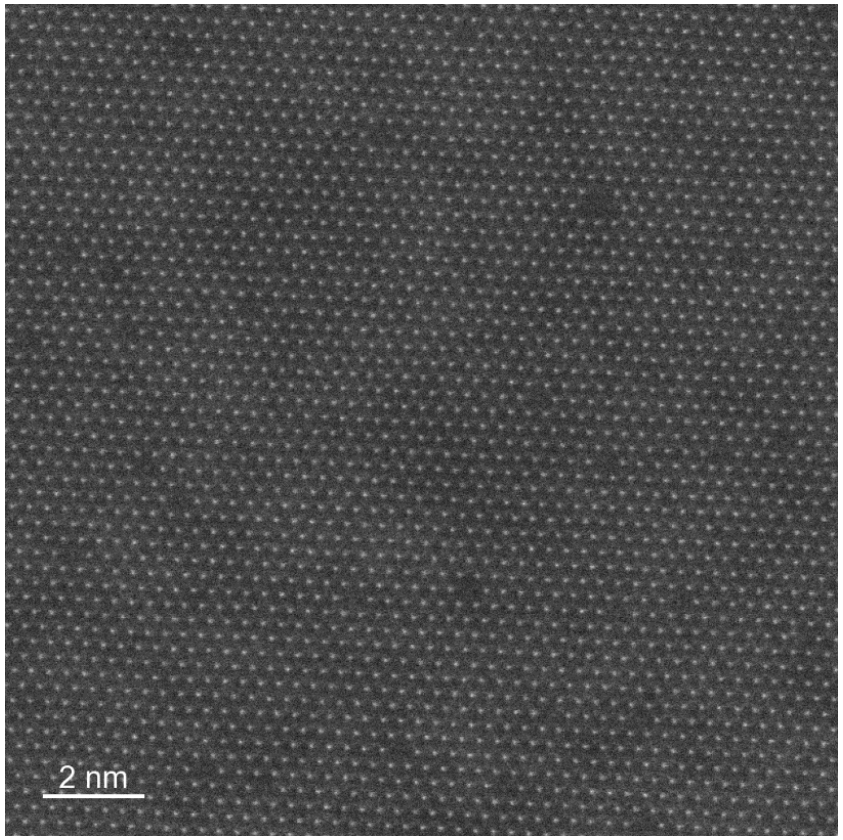


300 atomic positions

High Statistical Output in large Areas

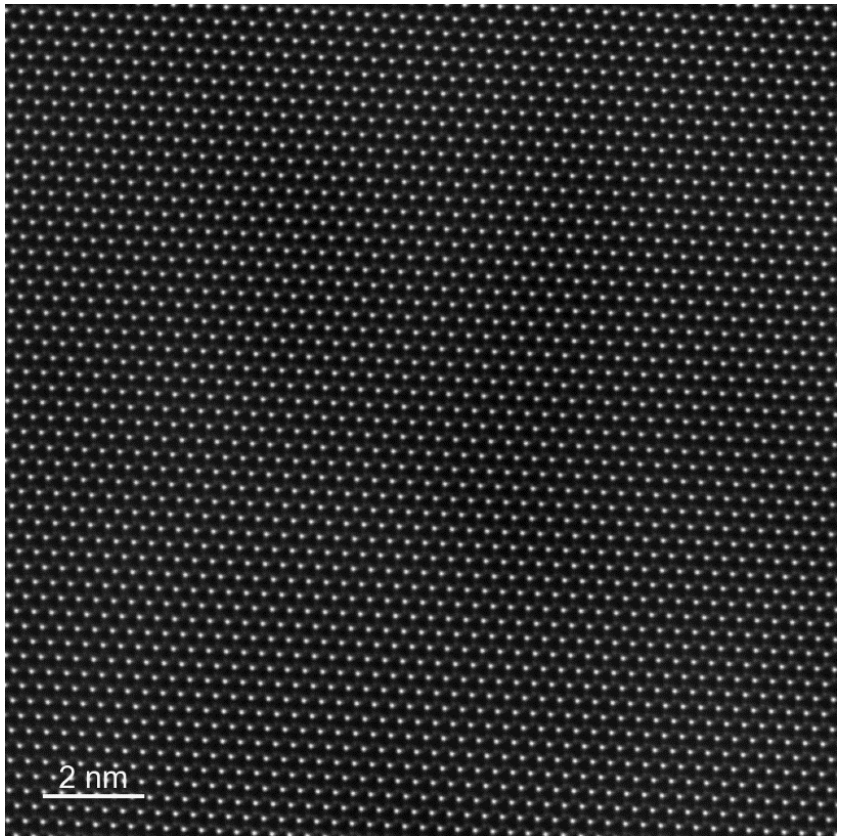


Original Image



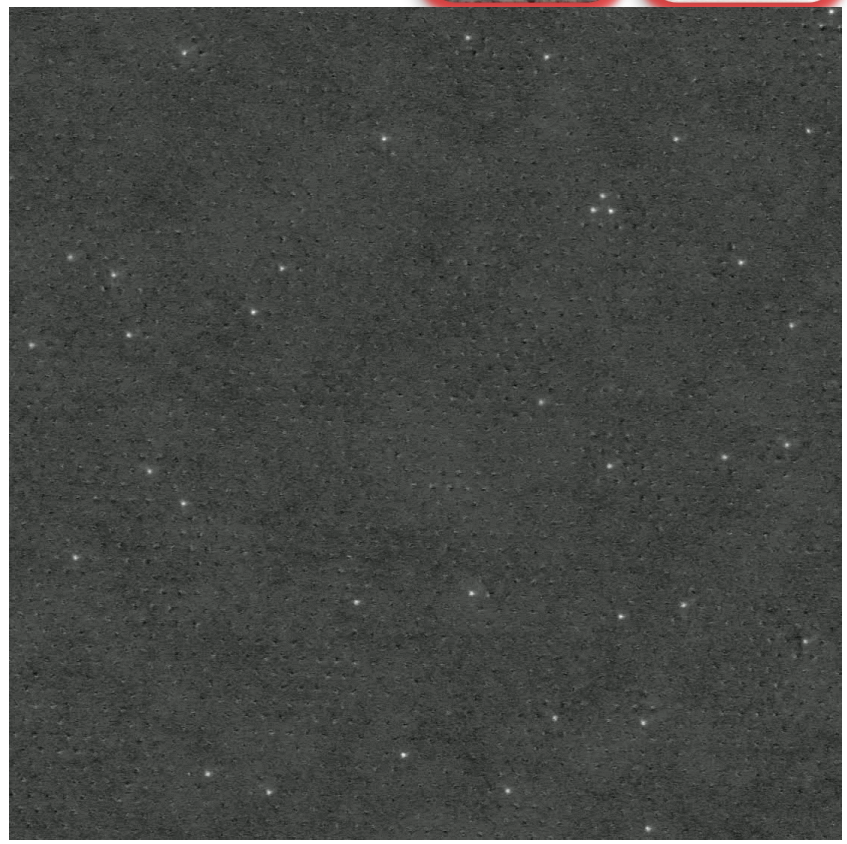
1.5 % of vacancies

Denoised Image



2503 atoms

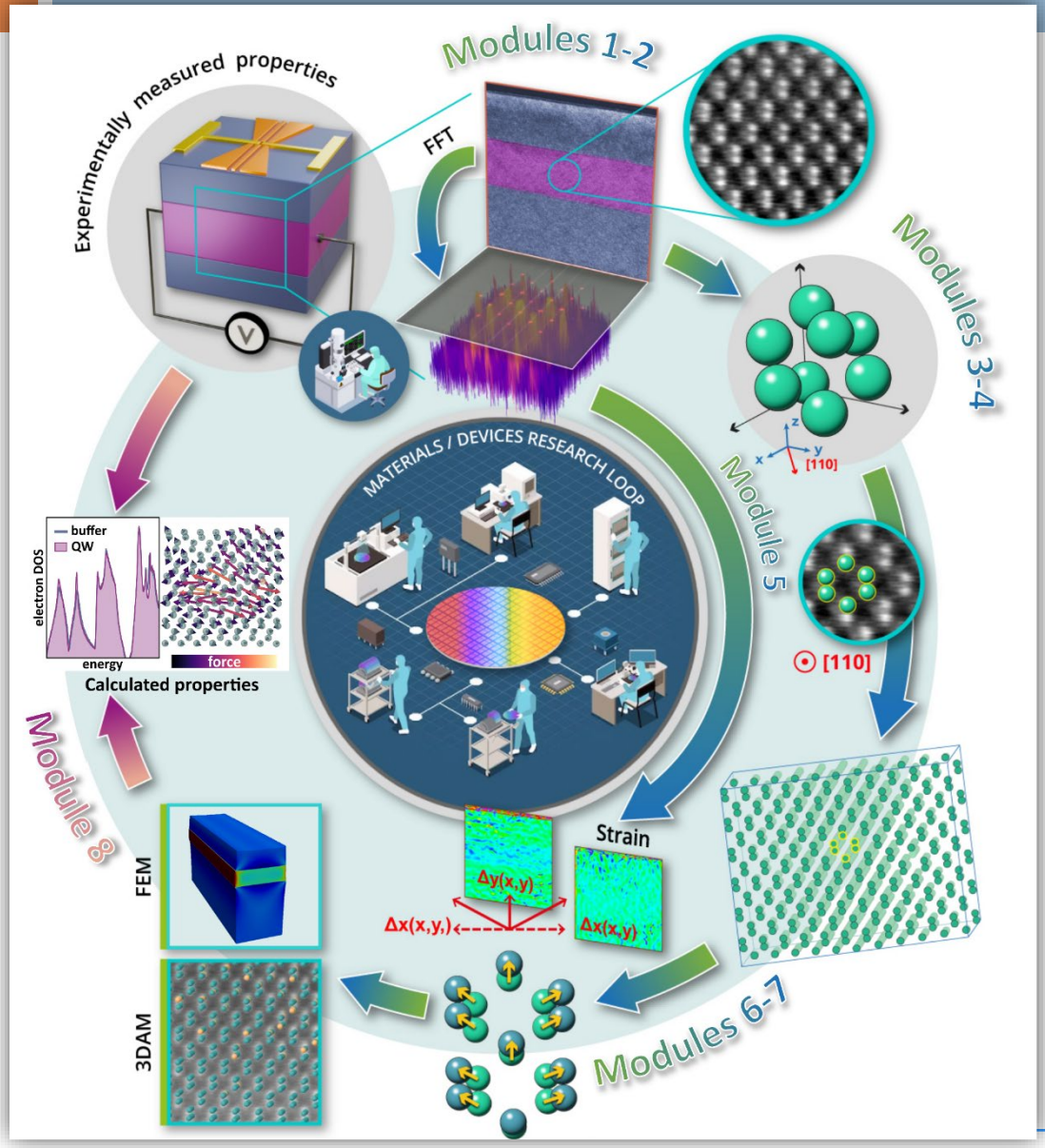
Vacancies Image



37 vacancies

- We've processed **images containing over 10,000 atoms** in **less than 30 seconds**.
- Within **1 hour**, we analyze **more than 100 images**, totaling **over 1,000,000 atomic positions**.

AI-automated workflow



Artificial Intelligence-Assisted Workflow for Transmission Electron Microscopy: From Data Analysis Automation to Materials Knowledge Unveiling

Marc Botifoll[1,*,†], Ivan Pinto-Huguet[1,†], Enzo Rotunno[2,*], Thomas Galvani[1], Catalina Coll[1], Payam Habibzadeh Kavkani[2,3], Maria Chiara Spadaro[4,5], Yann-Michel Niquet[6], Martin Børstad Eriksen[7], Sara Mart´ı-Sánchez[1], Georgios Katsaros[8], Giordano Scappucci[9], Peter Krogstrup[10], Giovanni Isella[11], Andreu Cabot[12,13], Gonzalo Merino[7], Pablo Ordejón[1], Stephan Roche[1,13], Vincenzo Grillo[2], and Jordi Arbiol[1,13,*]

Transferable to any materials/technology

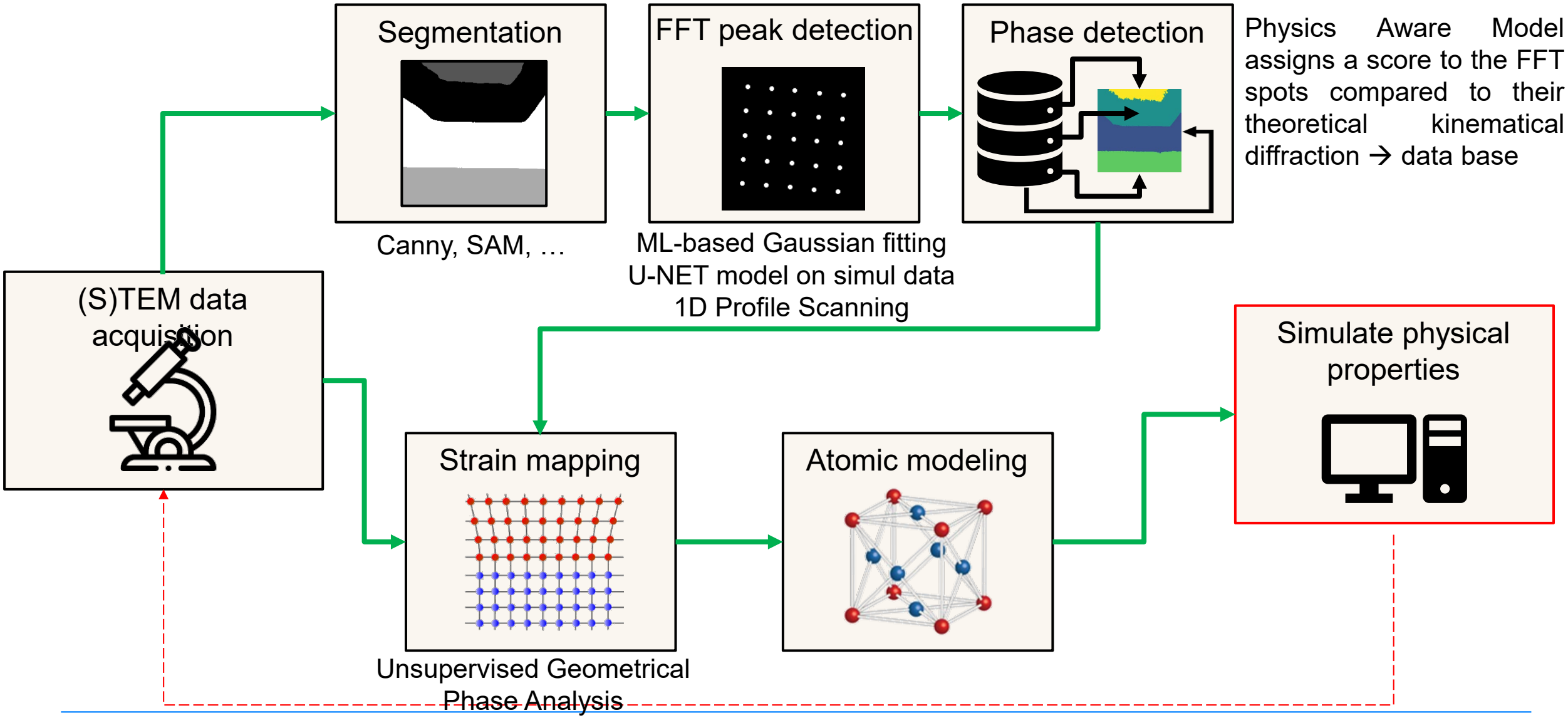
Enhanced characterization facilities

Self-driving labs

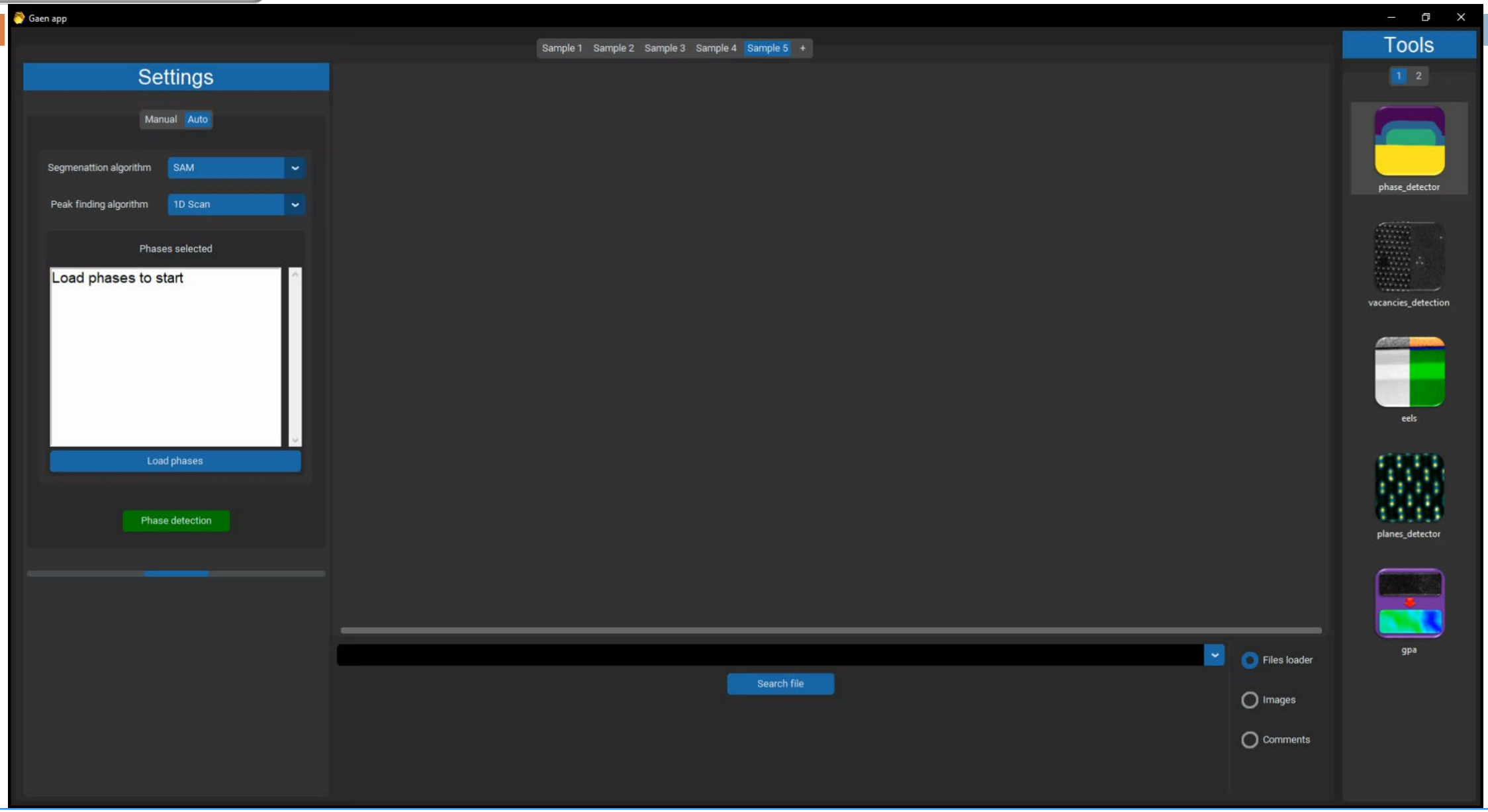
Fab equipment & Pilot lines

Adv. Mater. ***DOI: 10.1002/adma.202506785*** (2026)

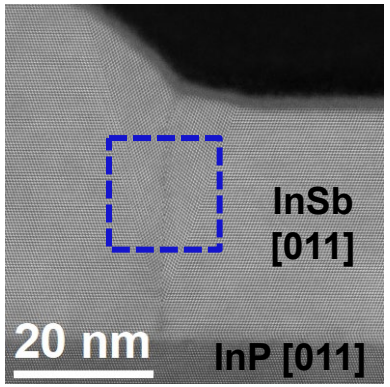
AI-automated workflow

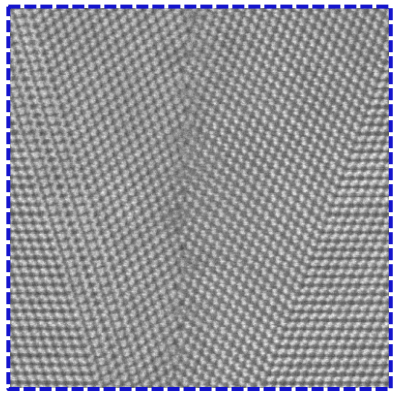


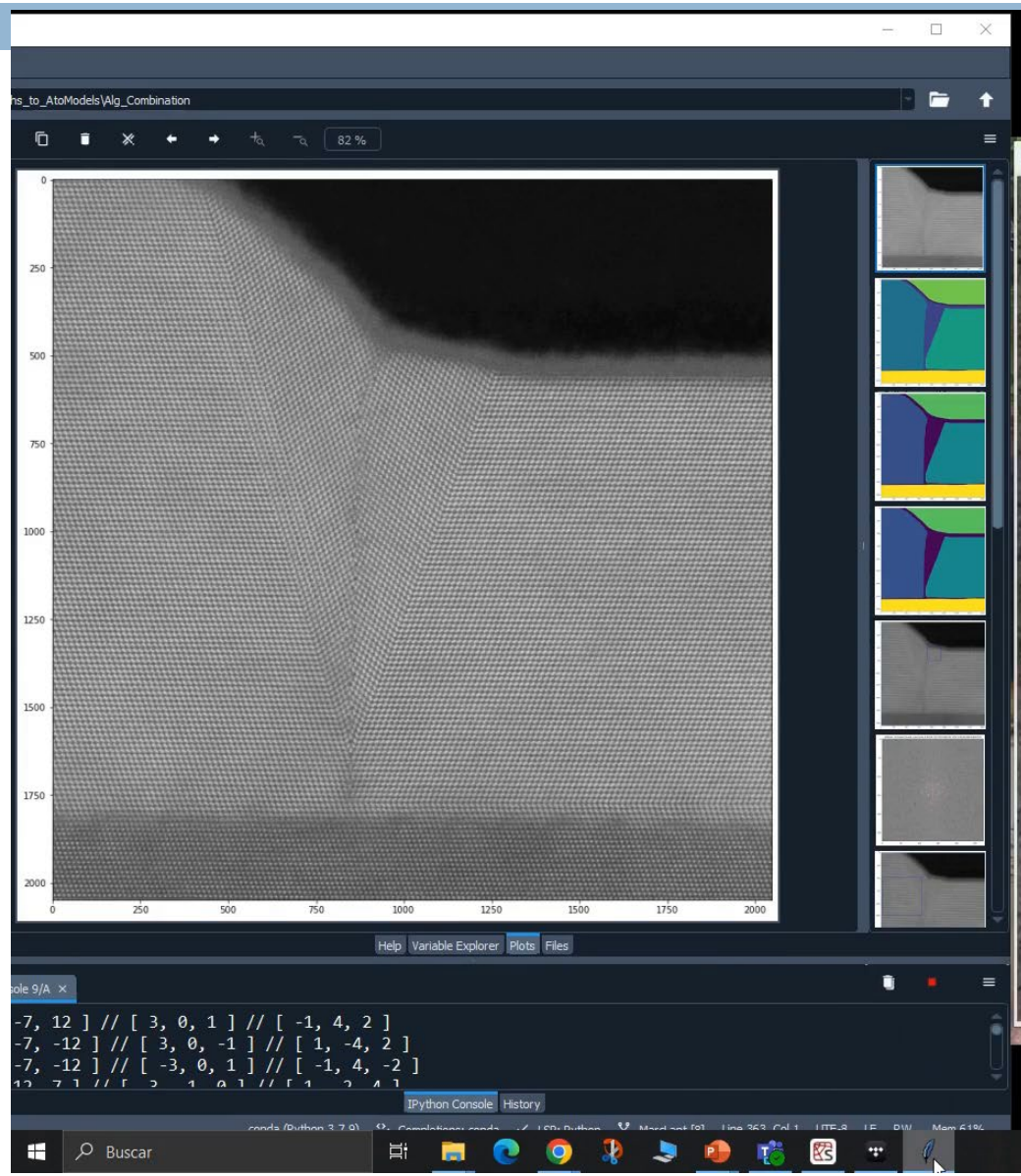
Part I: Data Analysis



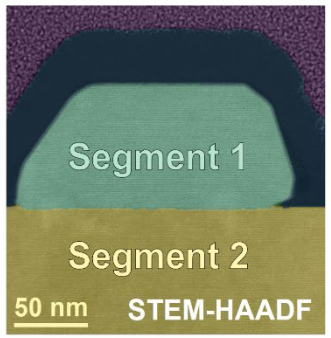
Part I: Data Analysis



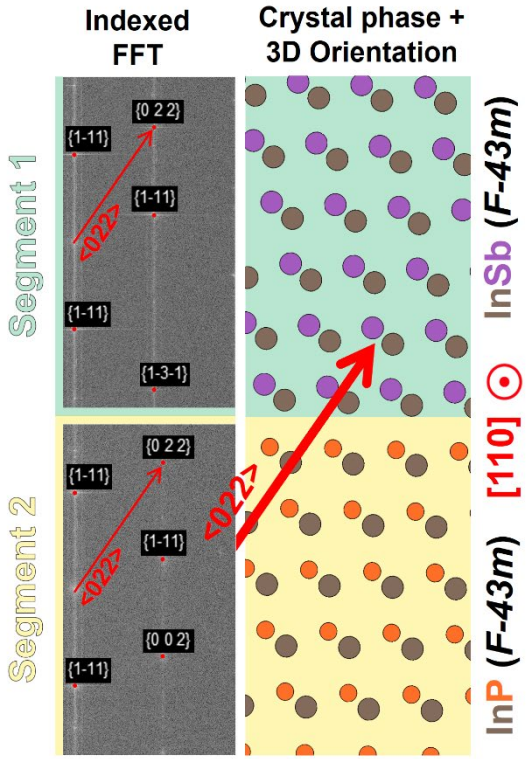


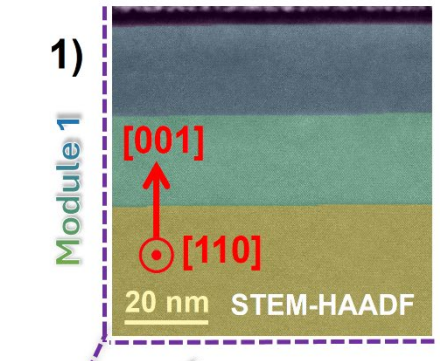


Part I: Data Analysis

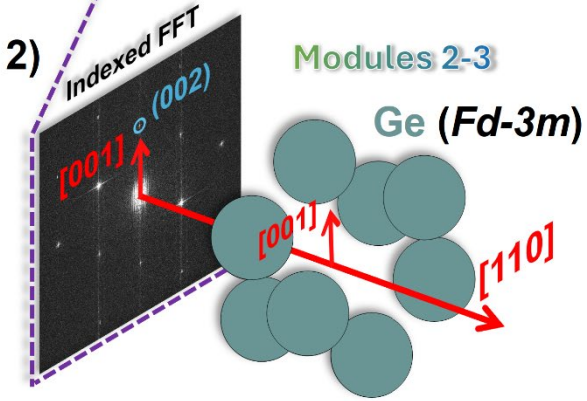


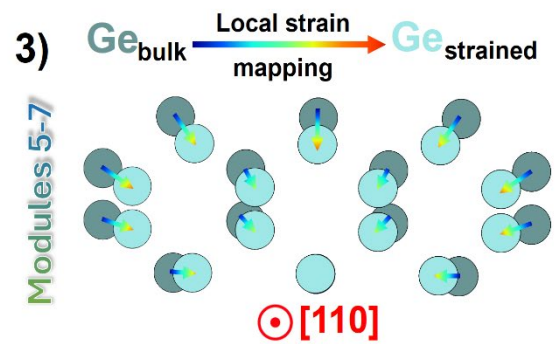
Segmentation (Canny)

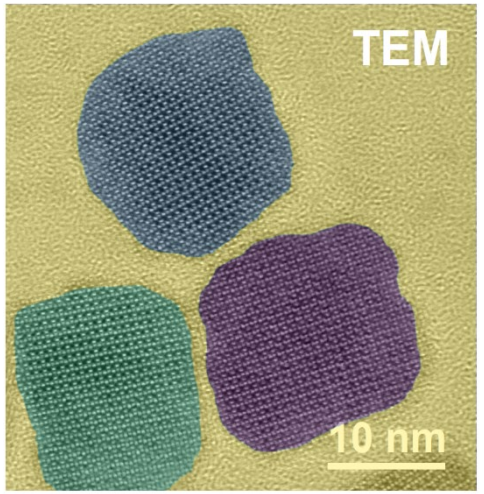




Segmentation (Canny)

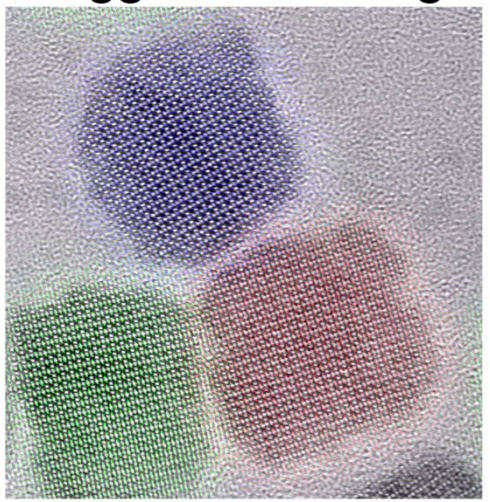






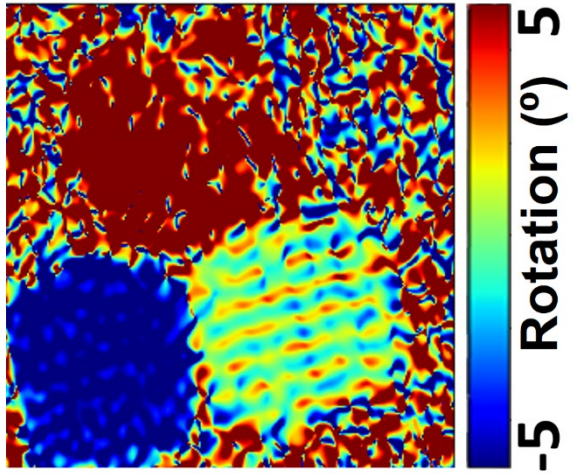
Segmentation (SAM)

Bragg-filtered image

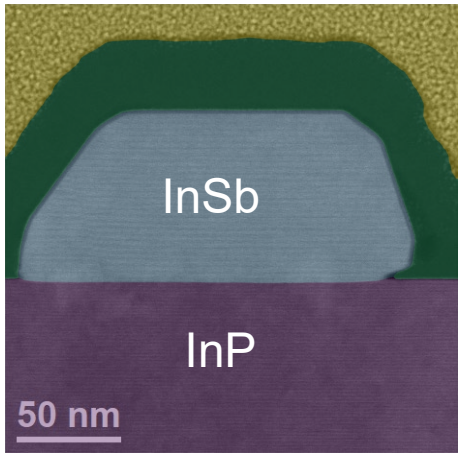


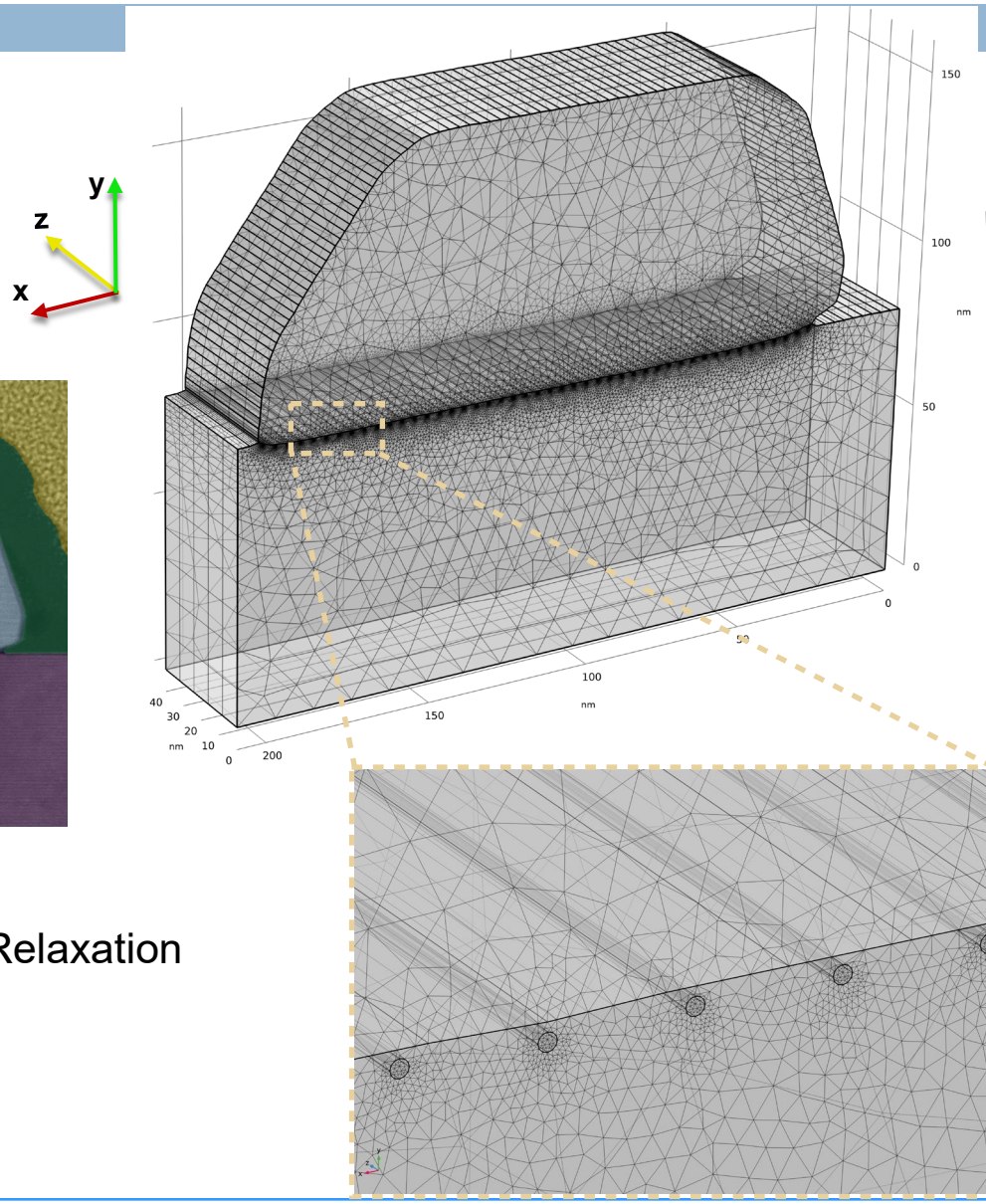
[001] ⊙ CuTe (Pm-3n)

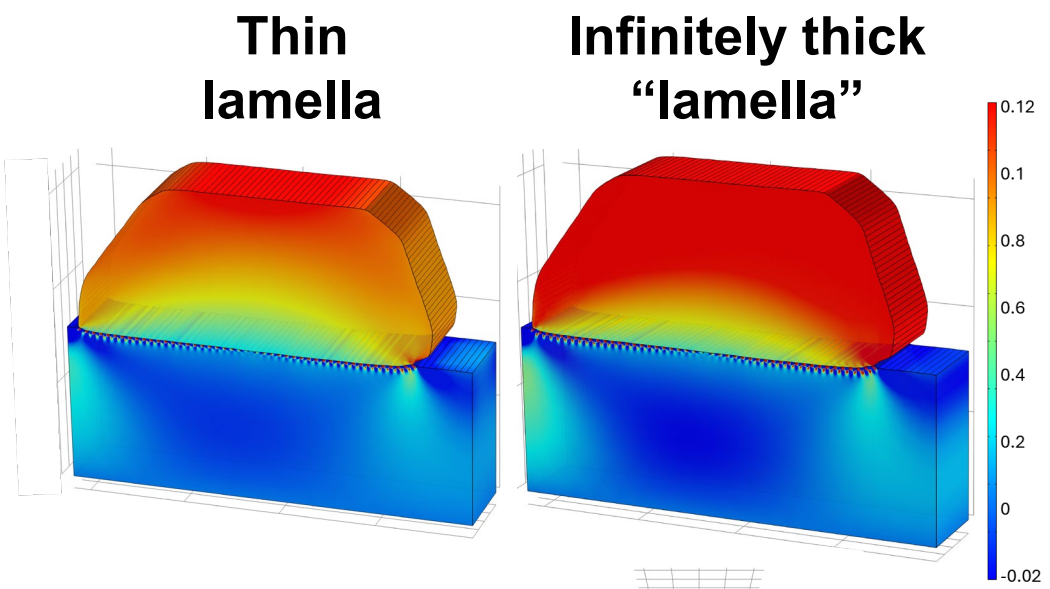
Strain: Rotation map

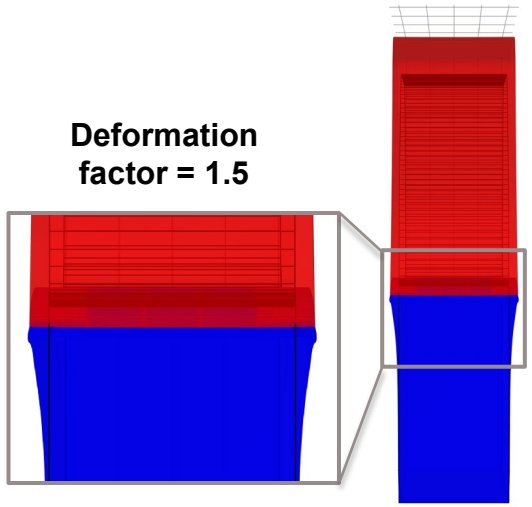


Part II: Modelling and simulations









- Finite Elements Relaxation calculations

Adv. Mater. ***DOI: 10.1002/adma.202506785*** (2026)

Part II: Modelling and simulations

STEM image

COORDINATES

EELS map

Si

$Ge_{0.7}Si_{0.3}$

$Ge_{0.97}Si_{0.03}$

COMPOSTION

Strain maps

STRAIN

3D Atomic Model (3DAM)

Structural model construction (zoom)

Positions of first planes (x_i, y_i, z_i) + Fractional occupations (α_i)

Replicate considering the occupancies

Randomly collapse atomic positions to Si/Ge

Si

Ge

[110]

[001]

53 nm

23469 atoms per plane

53 nm

[001]

[110]

[1-10]

Ge occupancy

1

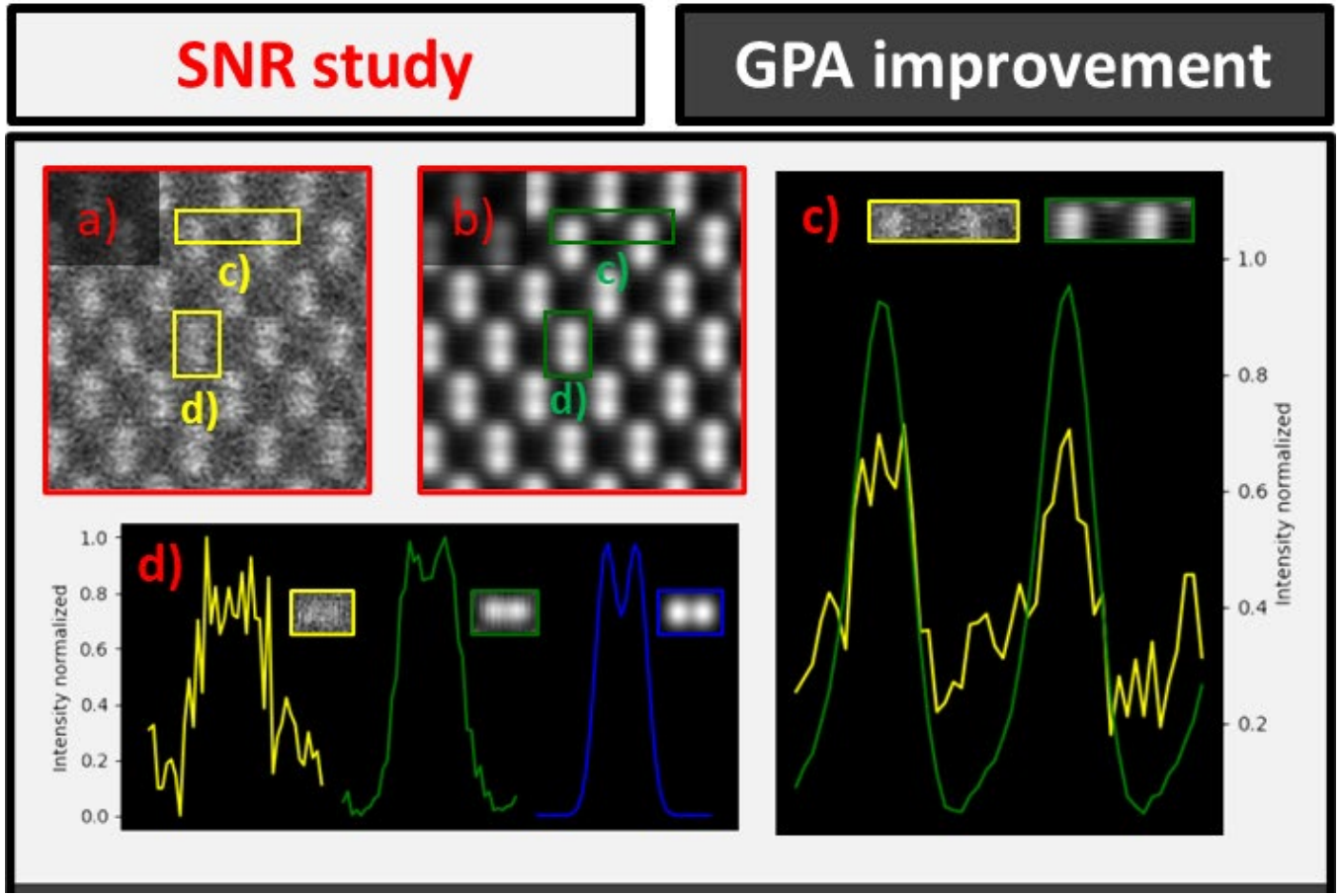
0

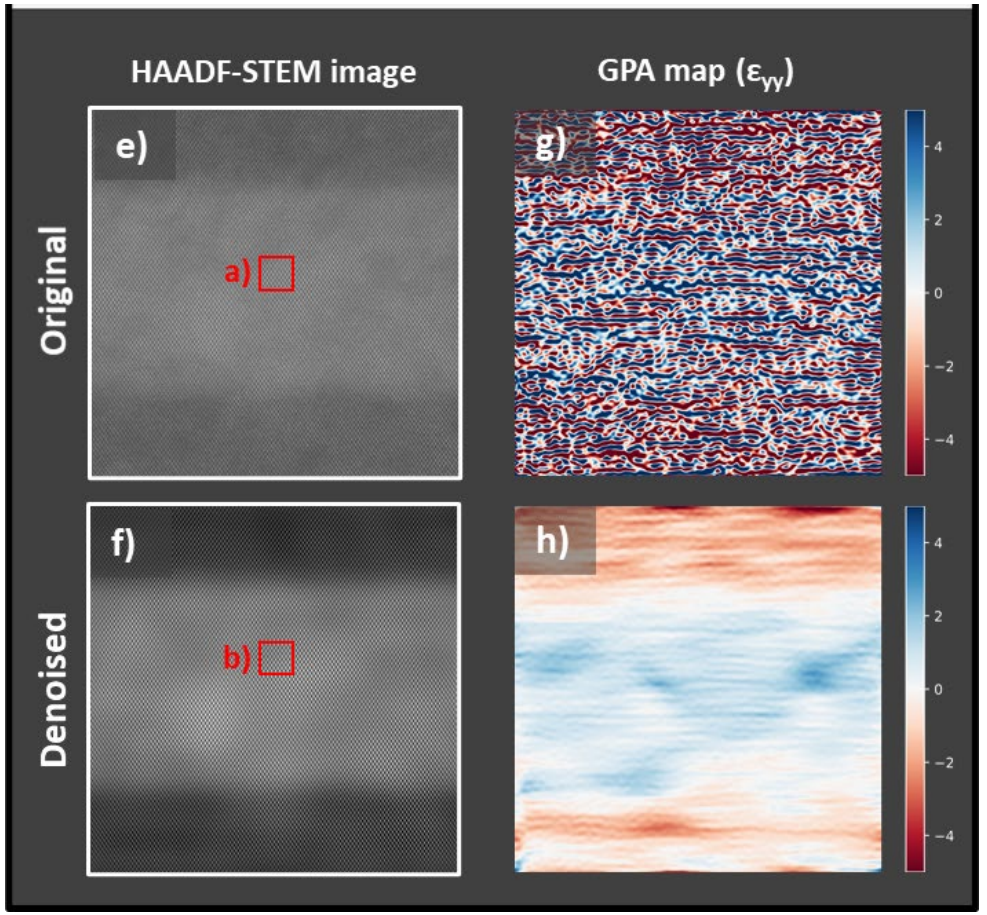
3D Atomic model (atomic positions)

Adv. Mater. ***DOI: 10.1002/adma.202506785*** (2026)

Part II: Modelling and simulations

Enhancing atomic-resolution in electron microscopy: A frequency-domain deep learning denoiser

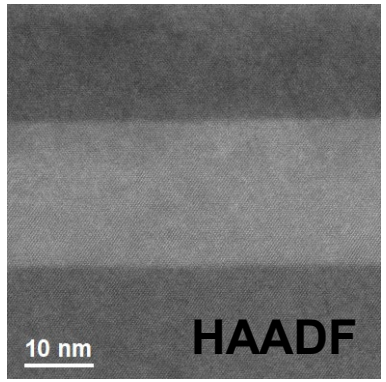




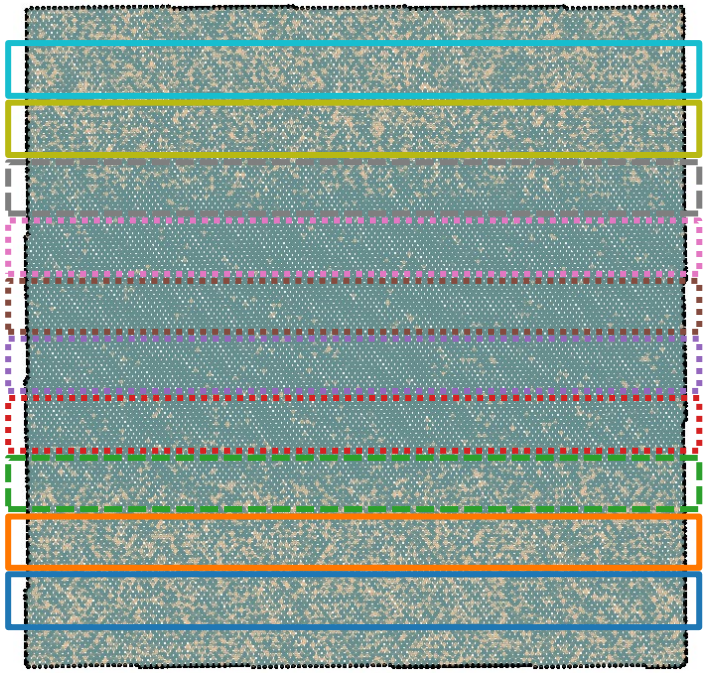
Adv. Intelligent Systems, ***DOI: 10.1002/aisy.202501077*** *(2026)*

Adv. Mater. ***DOI: 10.1002/adma.202506785*** (2026)

Part II: Modelling and simulations

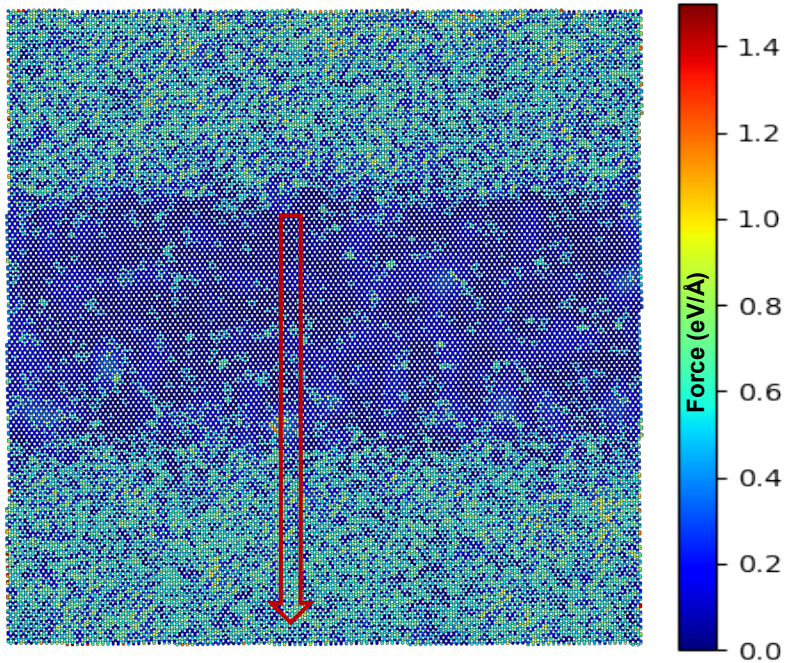


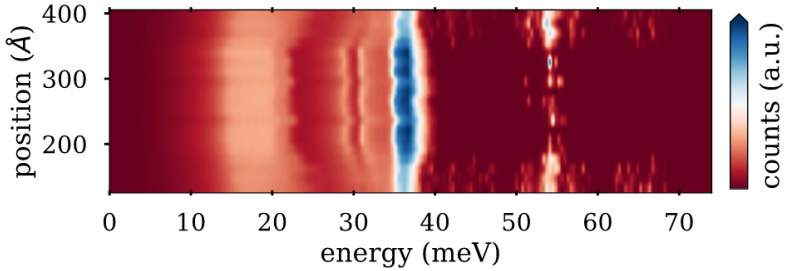
Atomic Keating Models → vibrational calculations



Ge Si H

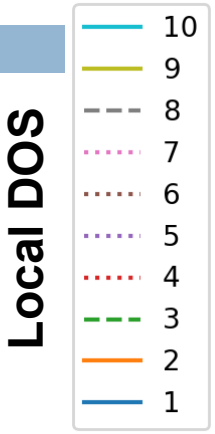
Atomic forces

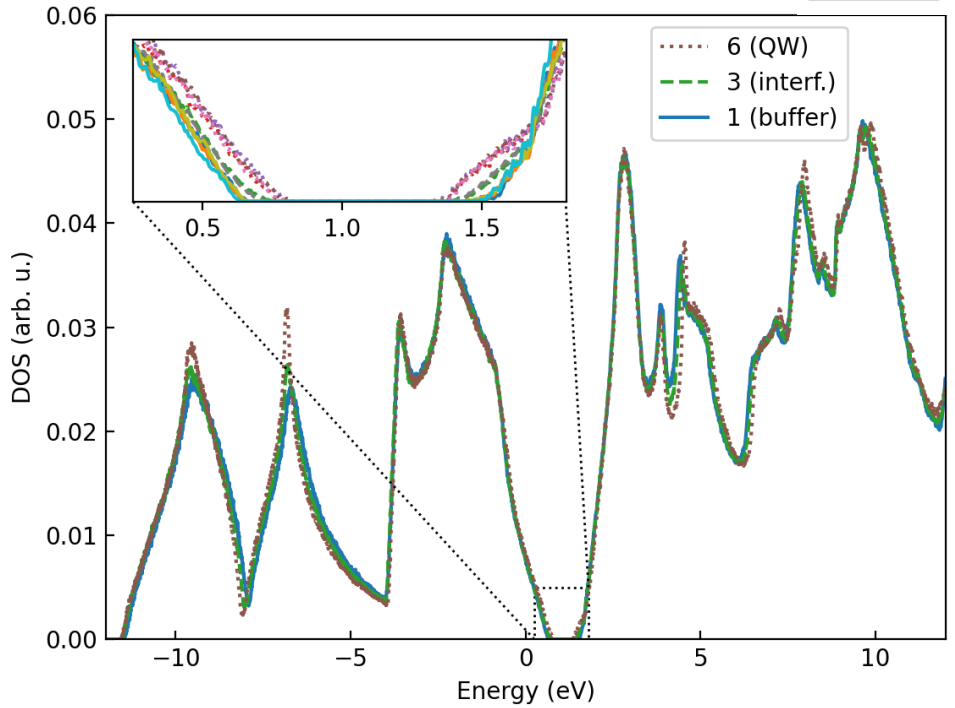




Phonon DOS

Electronic LDOS from precise 3DAM-based tight binding Hamiltonians computed by using linear scaling algorithms



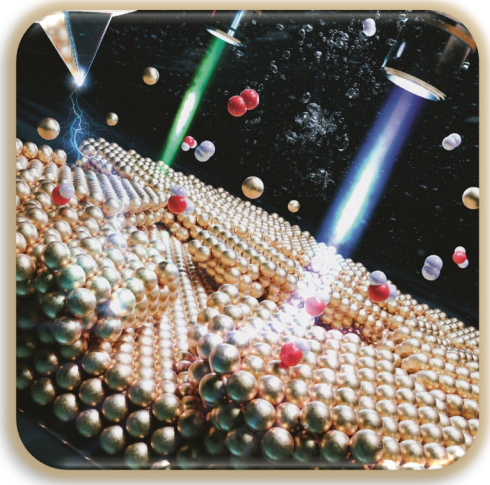


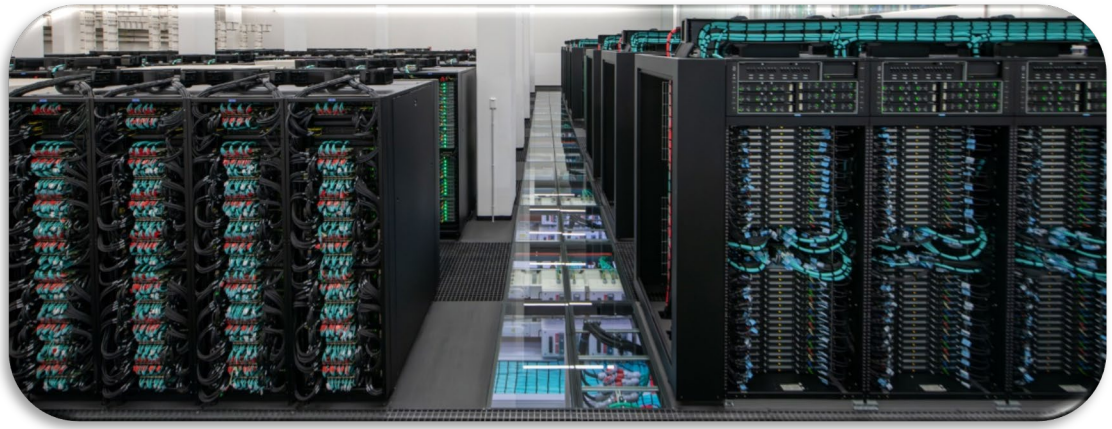
Adv. Mater. ***DOI: 10.1002/adma.202506785*** (2026)

In-CAEM Take Home Message

Future ways of integrating Multimodal, Multi lengh-scale and Correlative Techniques look promising: (S)TEM, Synchrotron and SPMs related imaging and spectroscopies.

AI automated data analysis combined with theoretical modeling can give statistical meaningful results on large systems (helping in-situ experiments as well)





Acknowledgements

Prof. J.R. Galán-Mascarós

Prof. P. García de Arquer

Prof. Z. Liu

Dr. Y.-M. He

Prof. A. Cabot

Prof. S. Barja

Prof. F. Fabregat

Prof. S. Giménez

Prof. H. Mas-Marzá

Prof. J.R. Morante

Quantum and Photonics

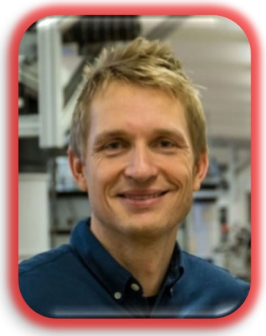
EPFL

Prof. A. Fontcuberta i Morral

Microsoft Station Q Delft

Dr. P. Caroff

NBI-NQCP



Prof. P. Krogstrup

DTU

Prof. T. Jespersen

DFM

Dr. S. Khan

מכון ויצמן למדע WEIZMANN INSTITUTE OF SCIENCE

Prof. E. Joselevich

Tsinghua University

Prof. Q. Xiong

Prof. C. Wang

FOM Institute AMOLF

Dr. E. Alarcon-Llado

IST AUSTRIA

Prof. G. Katsaros

TU Delft

Dr. G. Scapucci

Acknowledgements

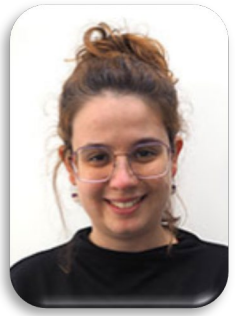
Dr. E. Rotunno

Prof. V. Grillo

Prof. S. Roche

Dr. T. Galvani

Prof. P. Ordejón



Dr. C. Coll

Prof. R. Dunin-Borkowski

Dr. M. Heggen

Prof. Q. Ramasse

Prof. J. García de Abajo

Acknowledgements

Prof. S. Bals

Dr. K. Jenkinson

Prof. Q. Ramasse

Prof. R. Dunin-Borkowski

Dr. M. Heggen

Prof. J. García de Abajo

Acknowledgements

Generalitat de Catalunya
Departament de Recerca i Universitats

Unió Europea
Fons Europeu de Desenvolupament Regional

Cat&Scale

Materiales avanzados

Next Generation Catalunya

Unió Europea
Fons Europeu Next Generation

SOLARUP

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Innovation Fund Denmark

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Funded by the Horizon 2020 Framework Programme of the European Union

- **EM Labs:** ICN2, CNRS (CEMES), Univ. Oxford, ER-C Jülich, EMAT Univ. Antwerp, CNR Trieste, Graz University of Technology, Norwegian University of Science and Technology

RIANA consortium

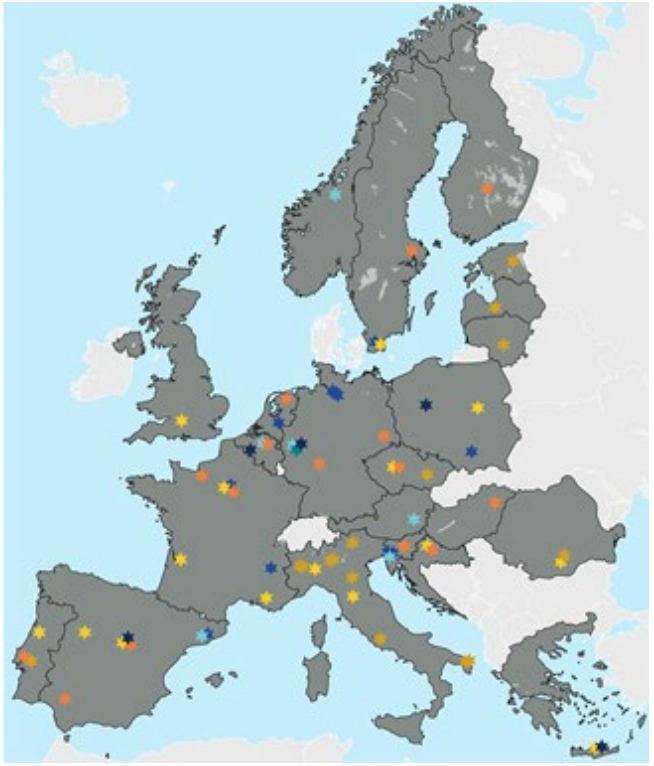
RIANA – Research Infrastructure Access in NAnoscience and nanotechnology

RIANA Consortium: **56 beneficiaries**
69 infrastructures
22 European countries

Duration: 48 months
(2024-03-01 – 2028-02-29)

Budget: 14.5 M€ + in-kind

Access offered: 35 748 h TA
5 000 000 h_{CPU}



Internationalization

"e-DREAM": European Distributed REsearch Infrastructure for Advanced Electron Microscopy

e⁻ DREAM
EUROPEAN DISTRIBUTED RESEARCH INFRASTRUCTURE FOR ADVANCED ELECTRON MICROSCOPY

ICN2 Institut Català de Nanociència i Nanotecnologia — EXCELENCIA SEVERO OCHOA

Universiteit Antwerpen

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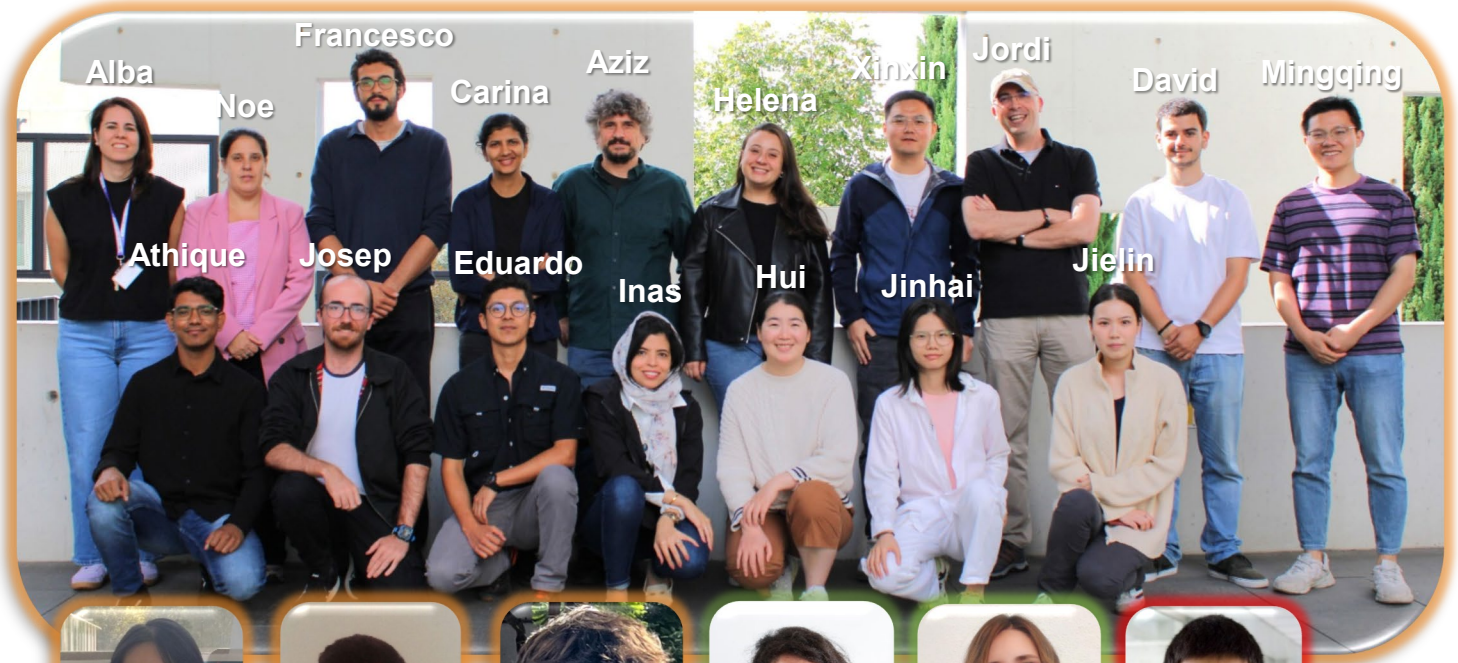
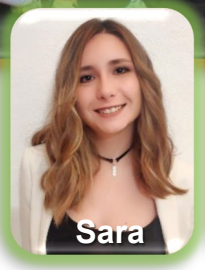
- **EM Labs:** ICN2, CNRS (CEMES), Univ. Oxford, ER-C Jülich, EMAT Univ. Antwerp, CNR Trieste, Graz University of Technology, Norwegian University of Science and Technology

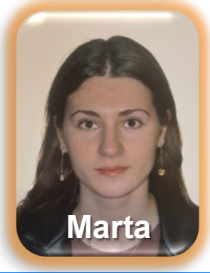
- **ICN2 as Founding Member of e-DREAM**

ACS Publications
Most Trusted. Most Cited. Most Read.

Advanced electron Nanoscopy (GAe-N)







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More about our research work, movies and models at:
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