250128 WISE NETWORKING MEETING 2025

MAX IV –opportunities for WISE research

Olof Karis, MAX IV Director

Materials research – A collaboration game!
Volvo, Alfa Laval, Tetra Pak…

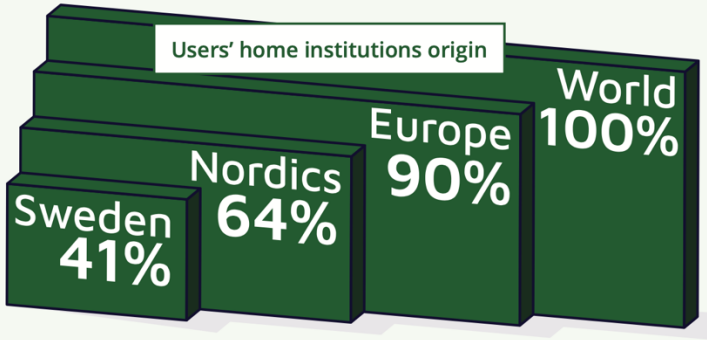
This is MAX IV

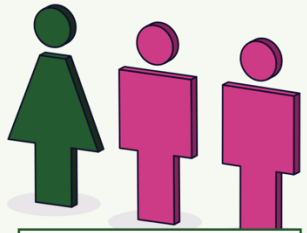
- A Swedish, national laboratory for X-ray research with Lund University as host
- A fourth-generation light source – up to 100 times brighter than the earlier generation and highly coherent
- Available for academic and industrial users worldwide

2024 beats 2023 and is the best year so far for MAX IV

USERS

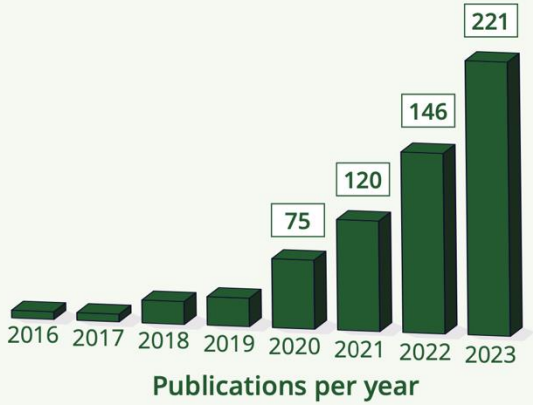
1732 unique users from **280** institutions across **34** countries out of which **14.7%** remote users



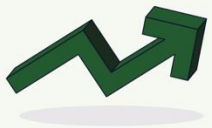


1 in 3 users is a female scientist

PUBLICATIONS



+51% increase of publications compared to 2022



651 publications 2016–2023

INDUSTRY

23 proprietary user groups including mediators

52% proprietary industry users from Sweden

~4950 hours of beamtime for user scientific projects connected with industry

~850 hours paid proprietary beamtime

EMPLOYEES

294 full-time equivalents

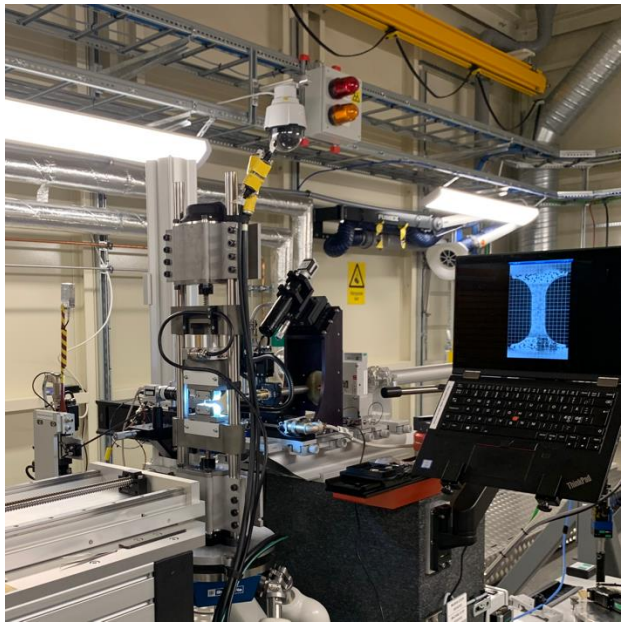
Dynamic structure

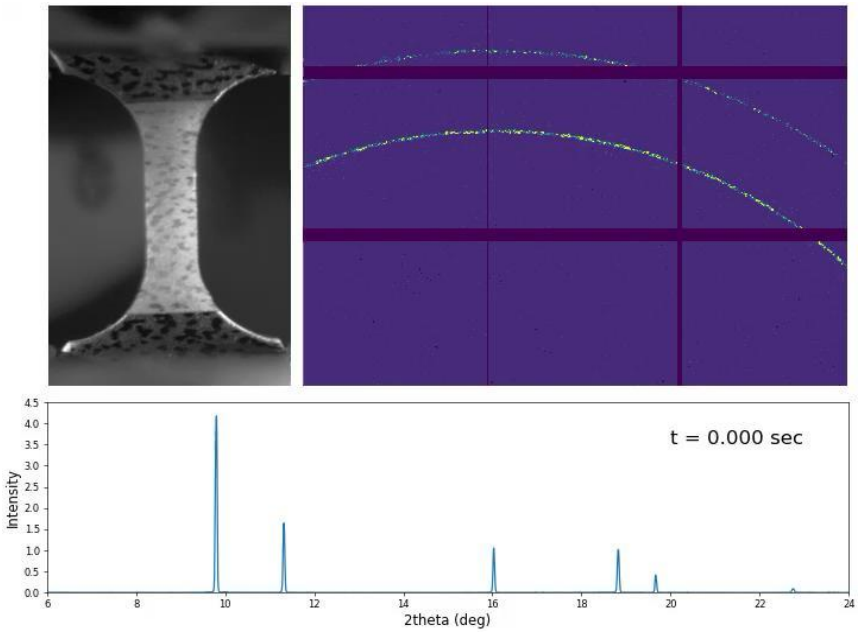
Structural changes by external triggers in two and three dimensions

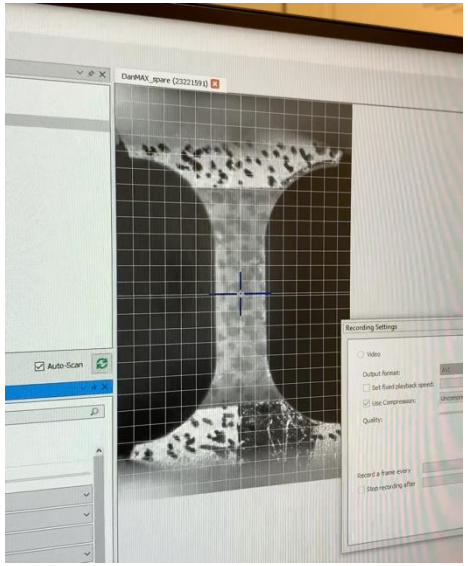
Phase transitions

Battery electrodes

Beamlines: DanMAX, ForMAX



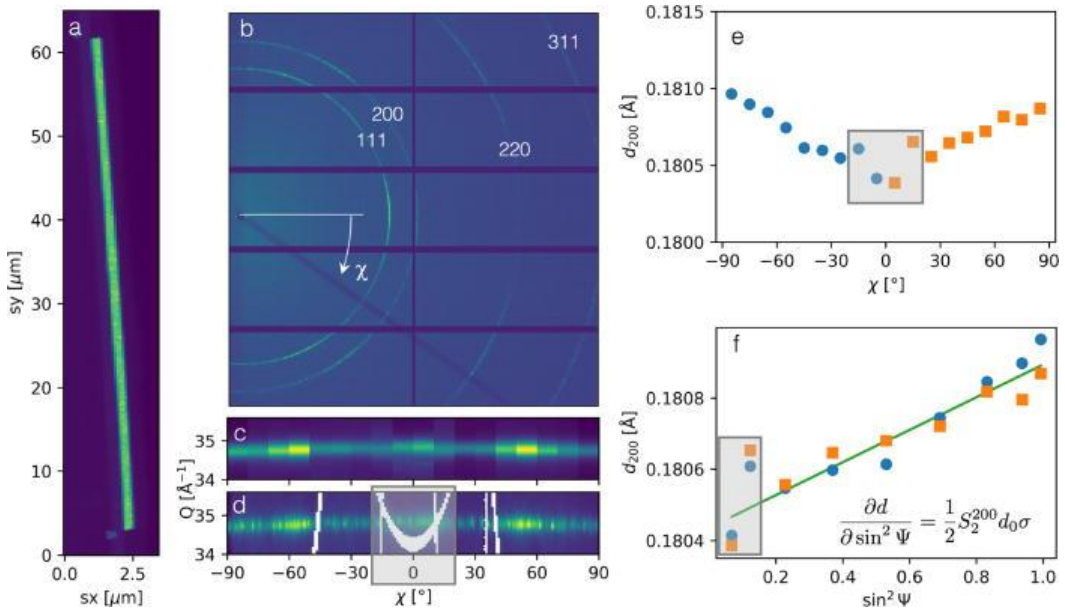


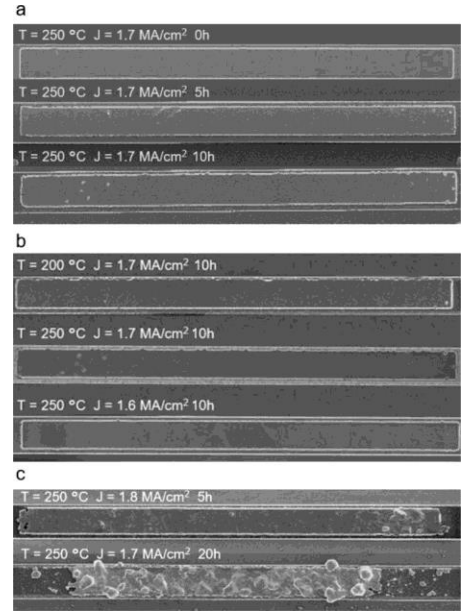


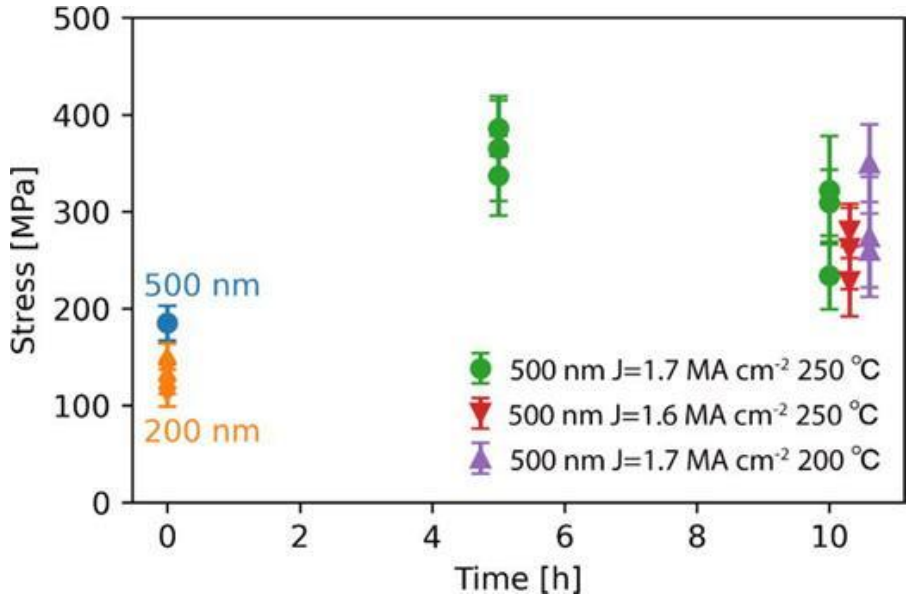
ADVANCED MATERIALS

Electromigration in copper interconnects

- Integrated circuits are becoming smaller with higher current densities leading to higher demands on the copper interconnects. One of the issues is electromigration.
- Copper structures subjected to various temperatures and currents were studied using nano-diffraction with a 62 nm beam at NanoMAX.
- Results suggest that early stages of electromigration is connected to stress from mismatch in material thermal expansion, but later in the process comes from current-induced stresses.







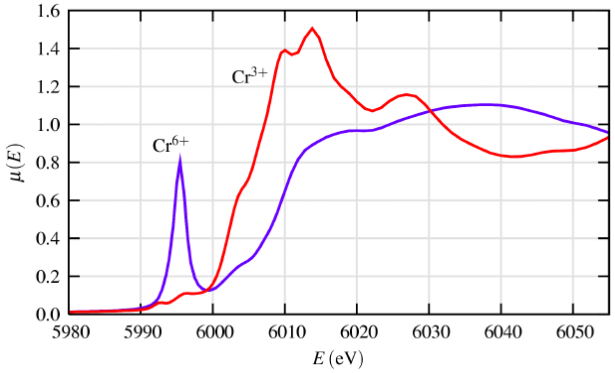
Publication
Y. Q. Zhang et al. Appl. Phys. Lett. 124, 083501 (2024)

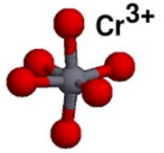
Read the science highlight

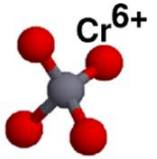
Bulk chemistry

Detailed information on chemical species and surroundings

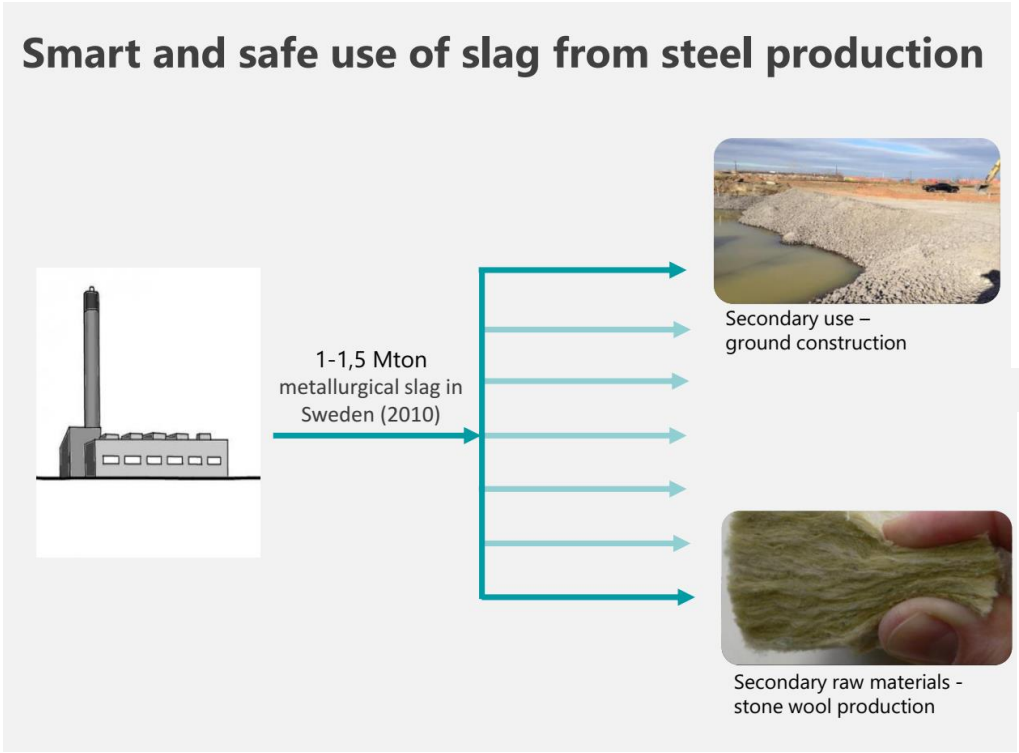
Beamlines: Balder, SoftiMAX, DanMAX, NanoMAX

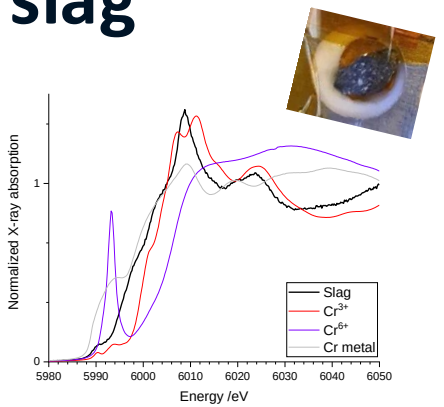


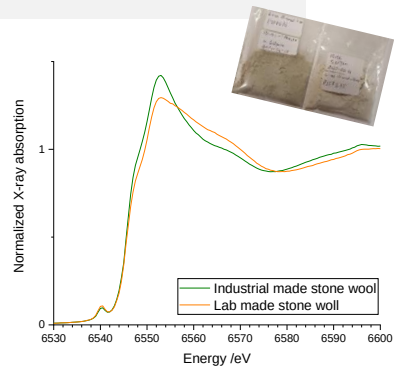




Industrial side streams – Steel slag



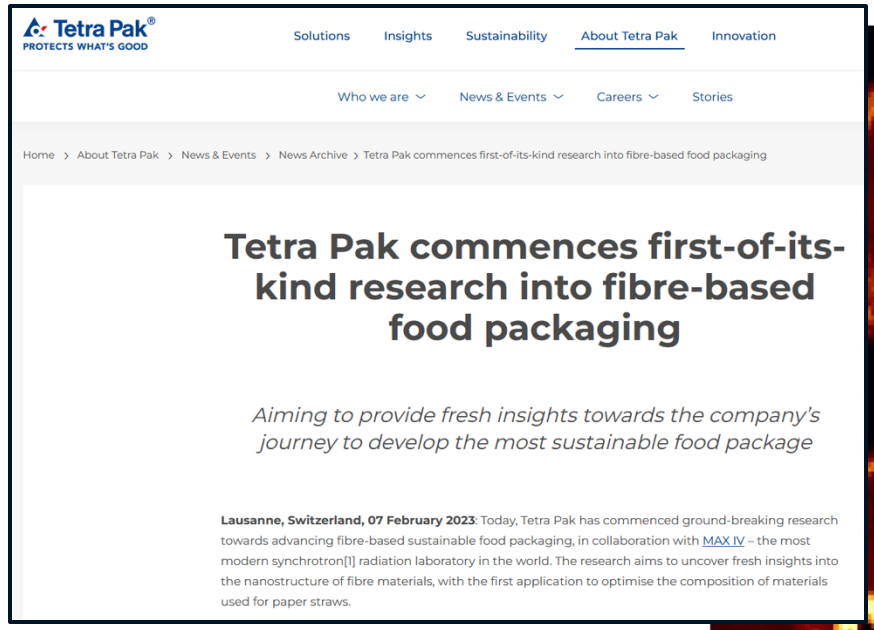




Imaging

Image with chemical/structural/magnetic contrast in 2 and 3 dimensions

Beamlines: DanMAX, NanoMAX, MAXPEEM, SoftMAX, ForMAX



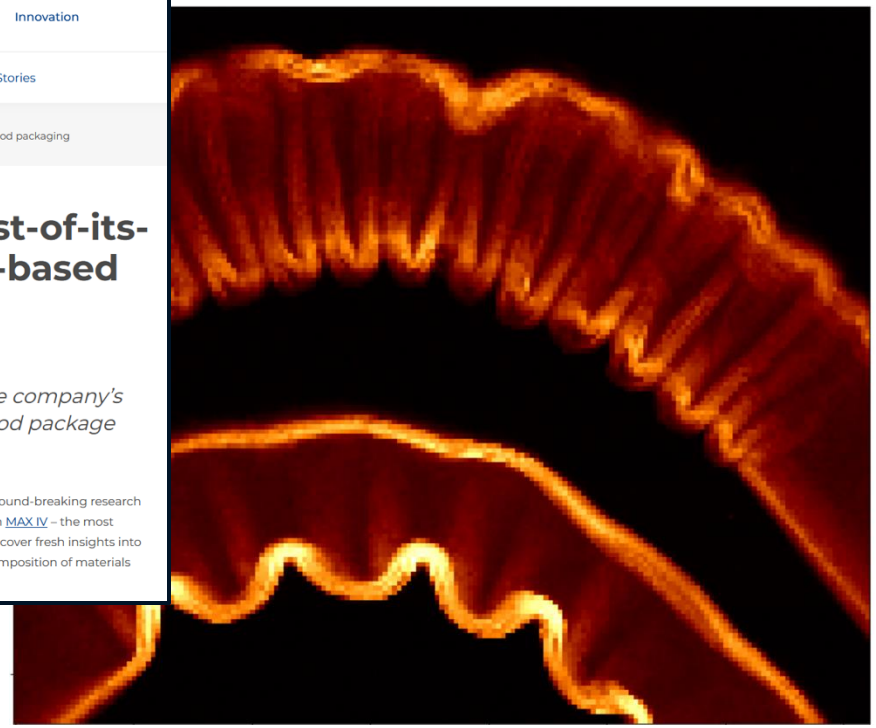


Image: Elin Persson Jutemar and Eskil Andreasson, Tetra Pak, in the ForMAX sample preparation lab at MAX IV. Credit: Anna Sandahl/MAX IV

Surface properties in vacuum

Oxidation

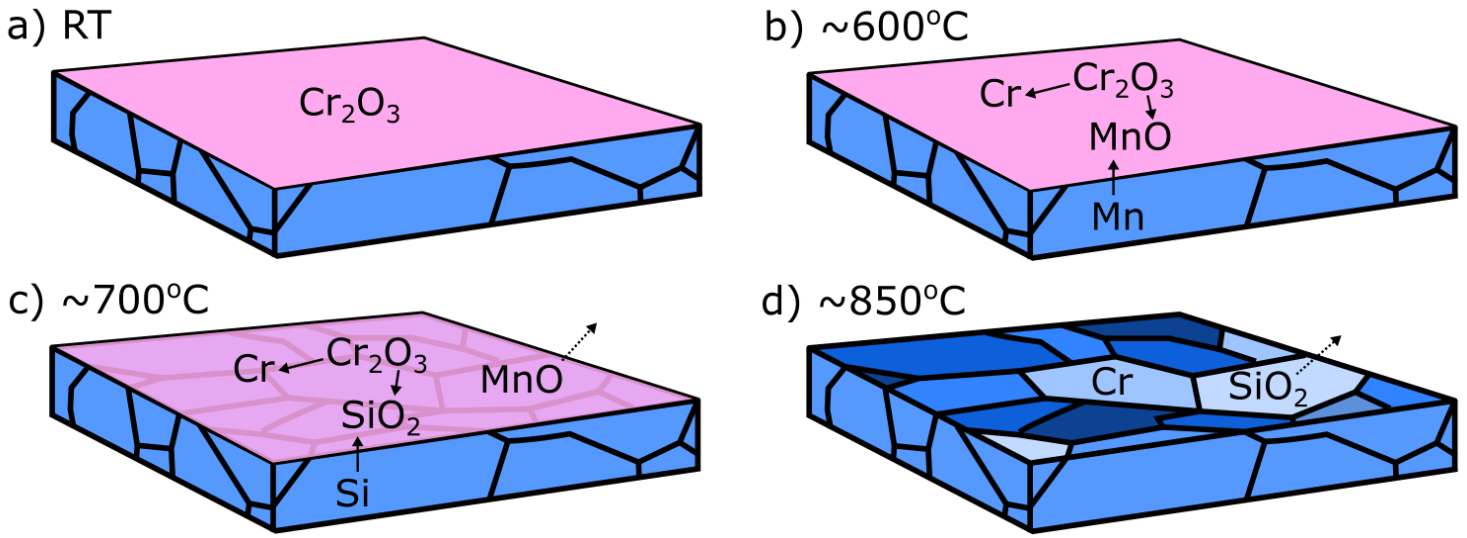
Fundamental catalysis

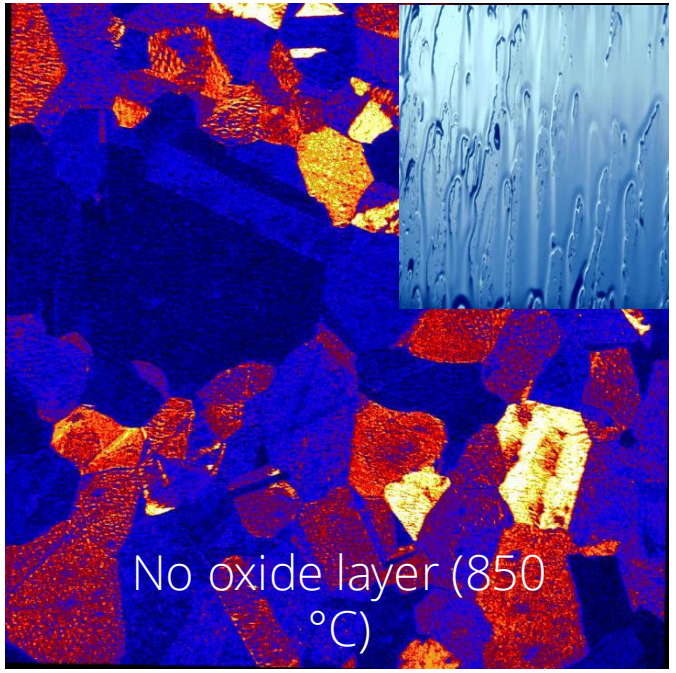
Aerosols

Functional surfaces

Beamlines: MAXPEEM, FlexPES, HIPPIE, SPECIES, FinEstBeAMS

Protective surface oxide layer of Stainless Steel



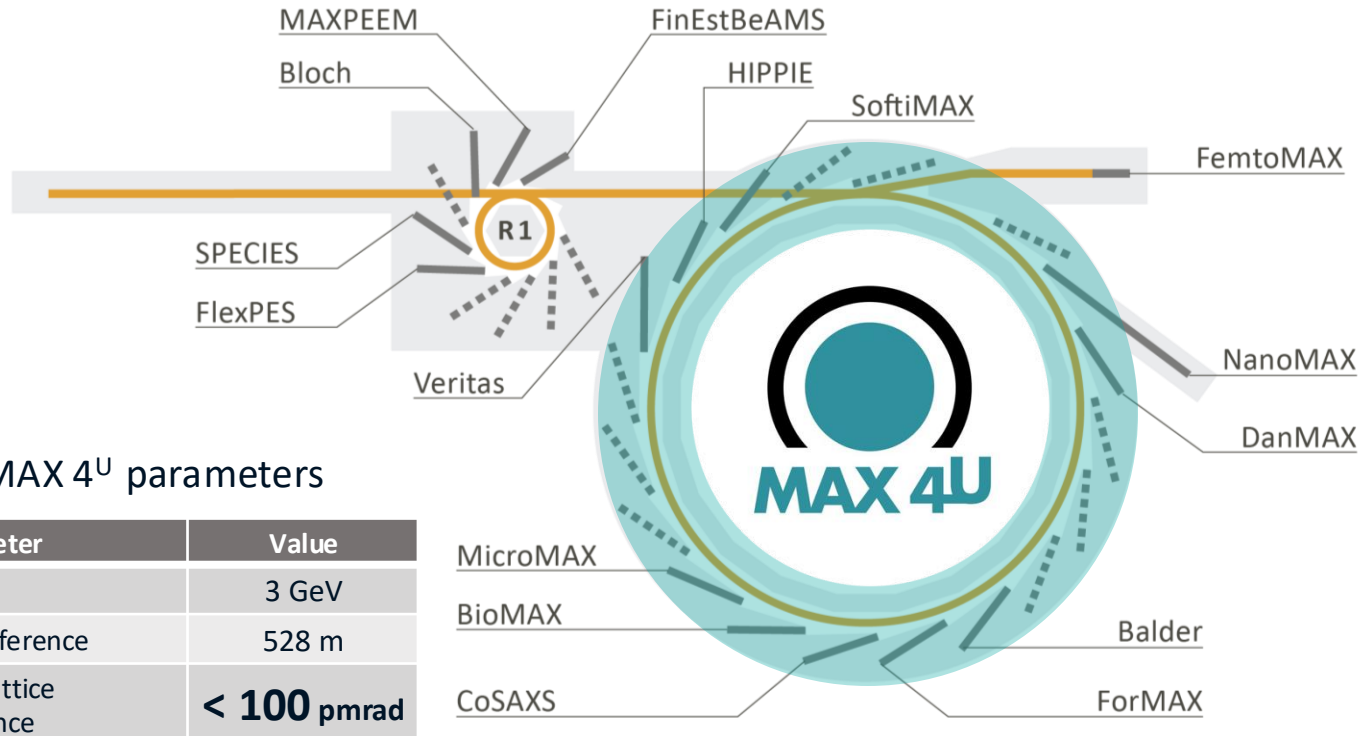


Figures: Alfa Laval

The future

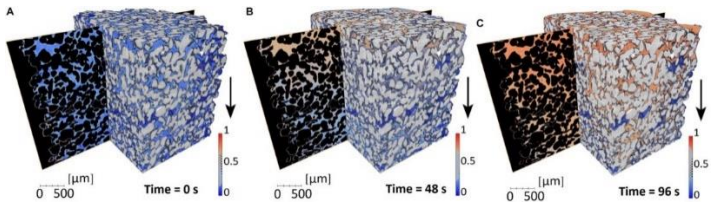
Looking forward

- MAX 4U accelerator upgrade
- Materials science beamlines in partnership with WISE
  - An imaging beamline supporting materials science for sustainability
  - A spectroscopy beamline supporting materials science for sustainability
- A medical imaging beamline

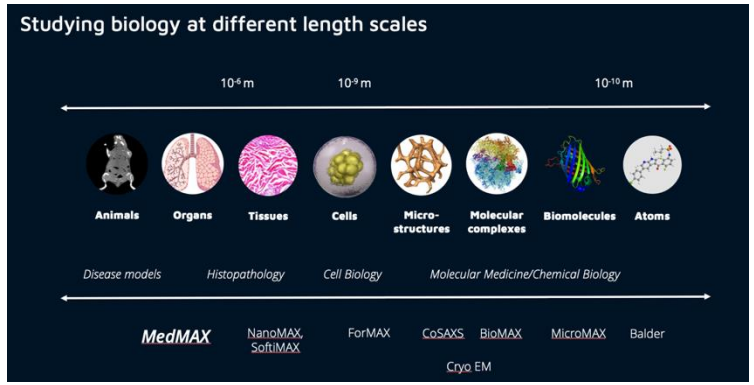


MAX 4U parameters

Parameter	Value
Energy	3 GeV
Circumference	528 m
Bare Lattice Emittance	< 100 pmrad

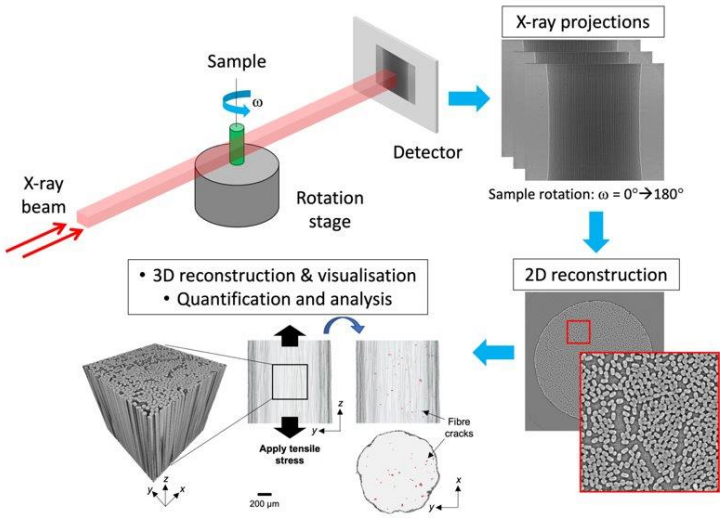


4D tomography time series showing solute transport at the pore scale (Marone et al., Front. Earth Sci., 2020)

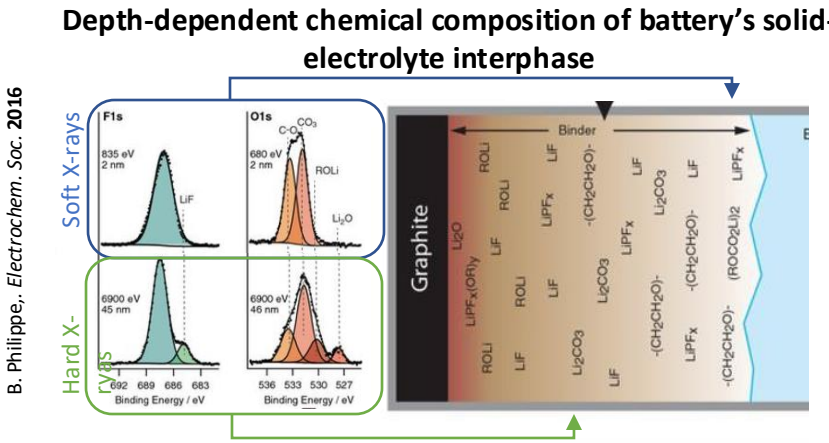


MAX IV – WISE Beamline Design

WISE funded development of 3 conceptual design reports in 2023.
2 proposed beamlines were selected to continue with technical design reports (TDRs).
Timeline: TDRs finished March 2025. Aim to open for first users 2029.



A dedicated **tomography** beamline enabling 4D imaging of materials with high spatial and temporal resolution.

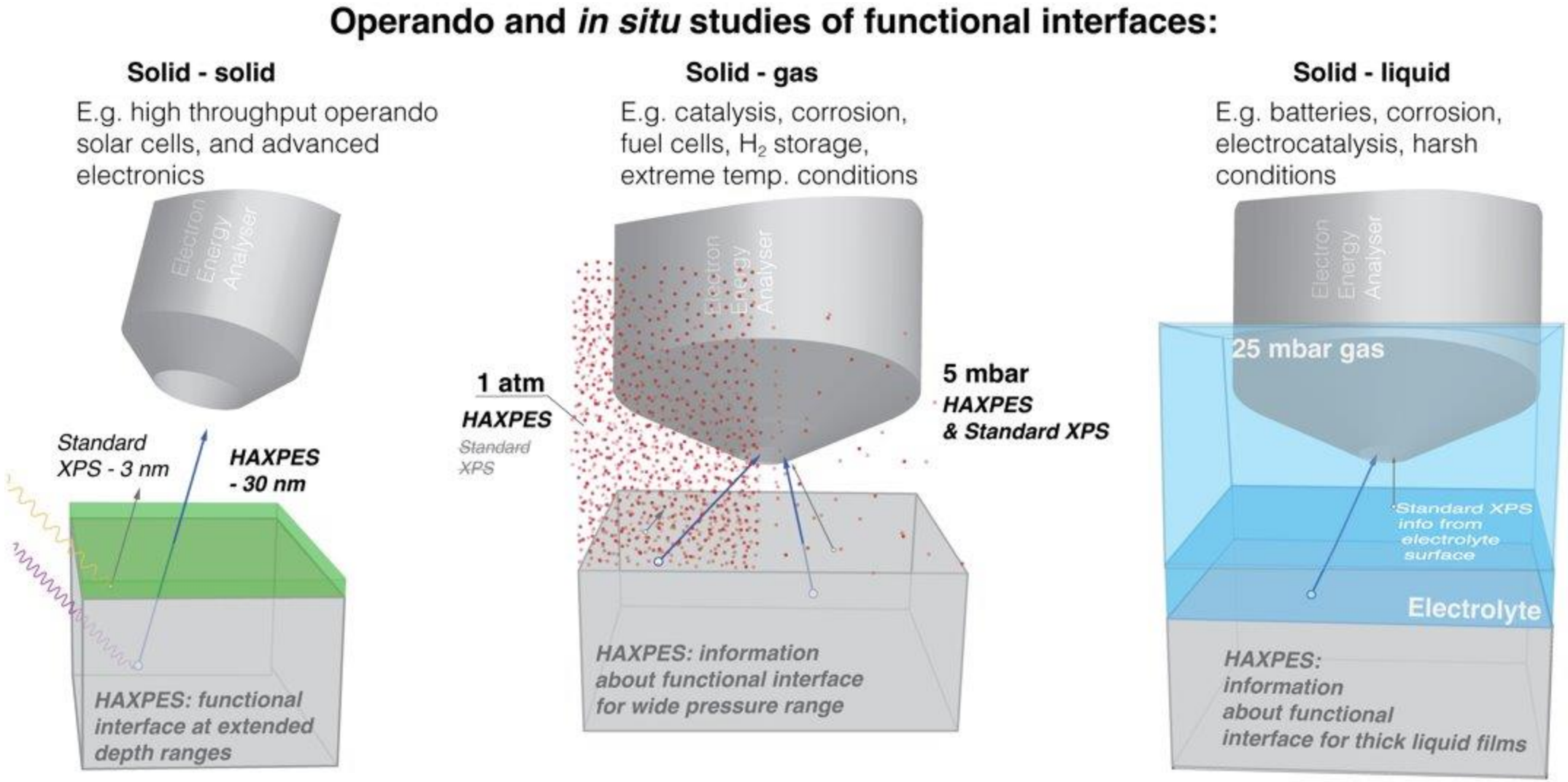


A HArd X-ray PhotoElectron Spectroscopy (**HAXPES**) beamline for chemical characterization of buried interfaces

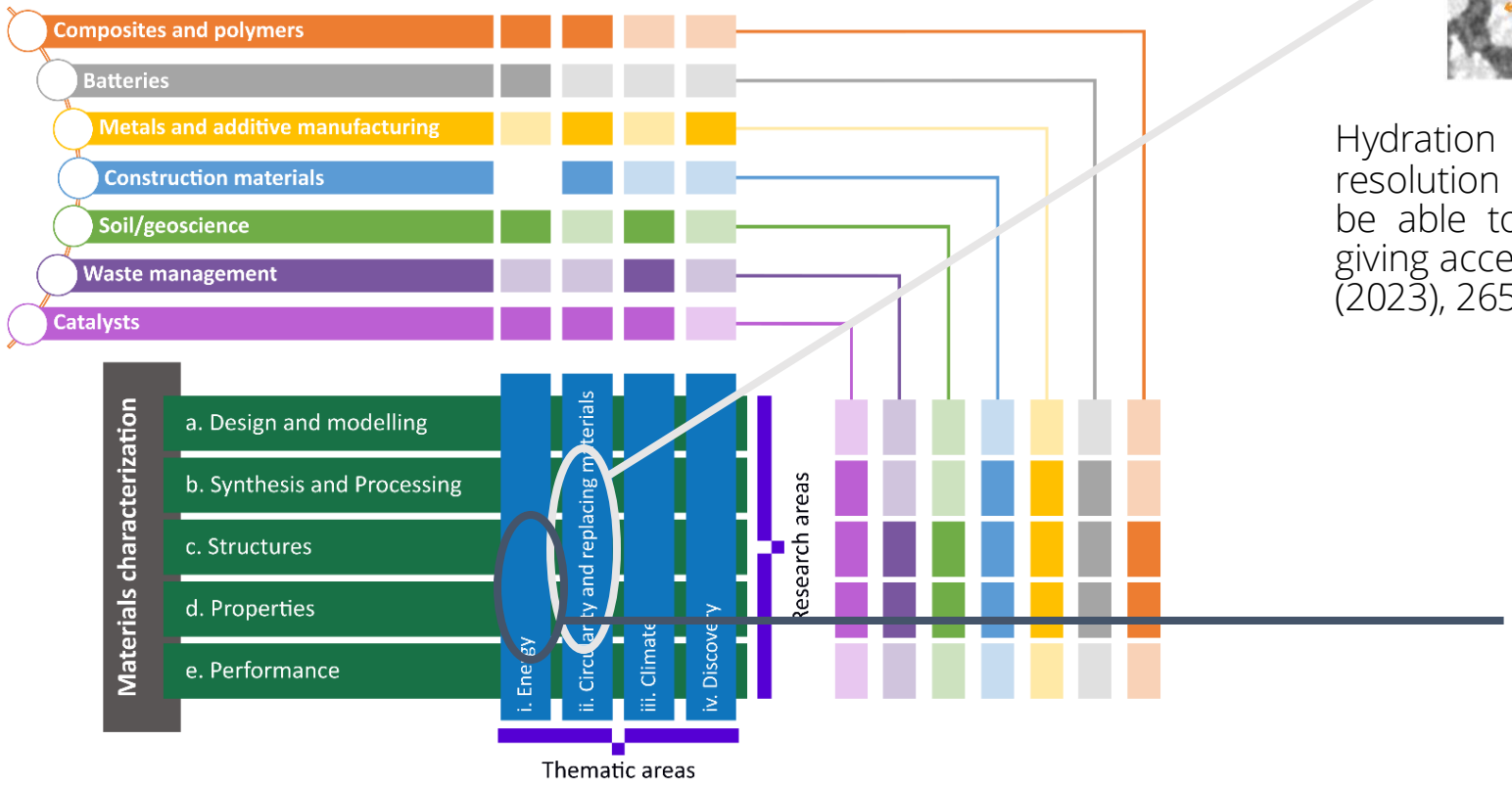
TDRs funded by

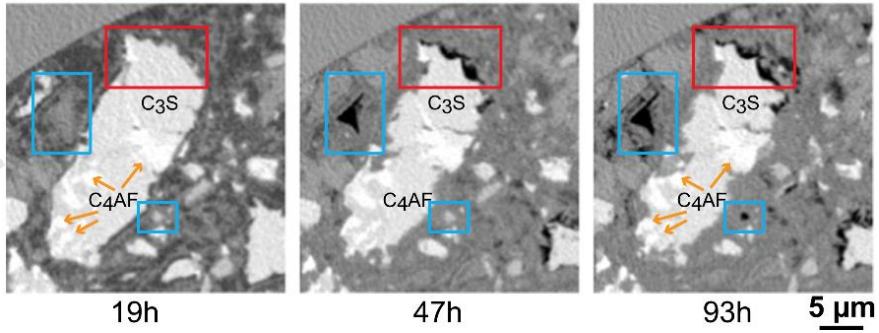
Wallenberg Initiative Materials Science for Sustainability

SpectroWISE Beamline – Science case

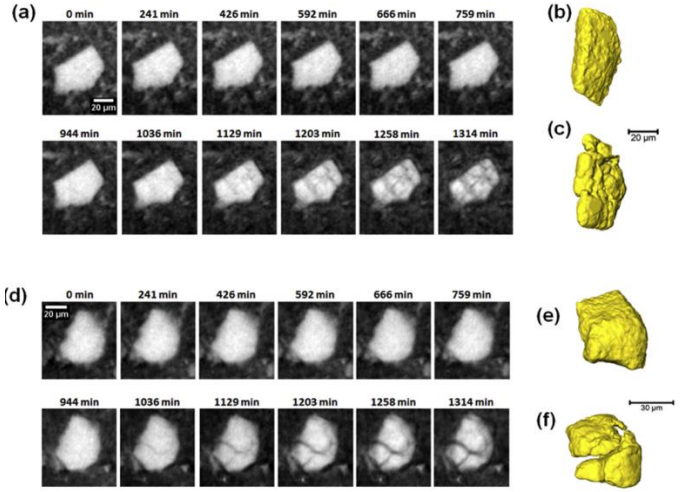


TomoWISE – Science Cases





Hydration of Portland cement studied with deep sub-µm resolution measured at the Swiss Light Source. TomoWISE will be able to perform similar measurements 100 times faster, giving access to the early stages of hydration [Nat. Commun. 14 (2023), 2652].

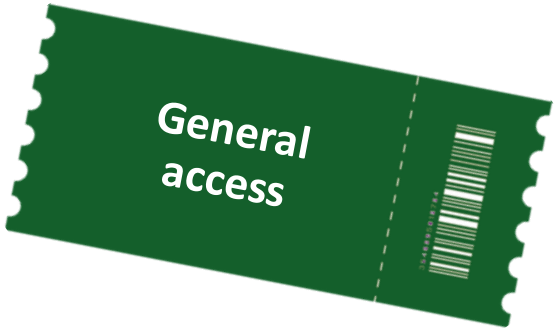


Crack propagation in nanoparticles of the Si electrode of a Li-ion battery measured during lithiation. Similar studies will be possible to do with higher spatial and temporal resolution at TomoWISE [J.Power Sources 342 (2017) 904–912].

What it means for industry

- Study raw materials behaviour and properties at **unprecendented resolution**
- Enable radical **product optimisation**
- Improve **manufacturing processes**
- Obtain **input and data** for computational modelling, patents, marketing, etc.
- Gain new insights – **transform and accelerate** your business

Two ways to become a user



- ✓ Free
- ✓ Apply for experiment time (2 open calls/year)
- ✓ Collaborate with an academic research partner
- ✓ Proposals ranked on scientific merit
- ✓ Publish your results

- ✓ Paid
- ✓ Faster, industry-tailored access
- ✓ Full confidentiality and IP rights
- ✓ One time project or long-term framework agreement
- ✓ You own your results

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