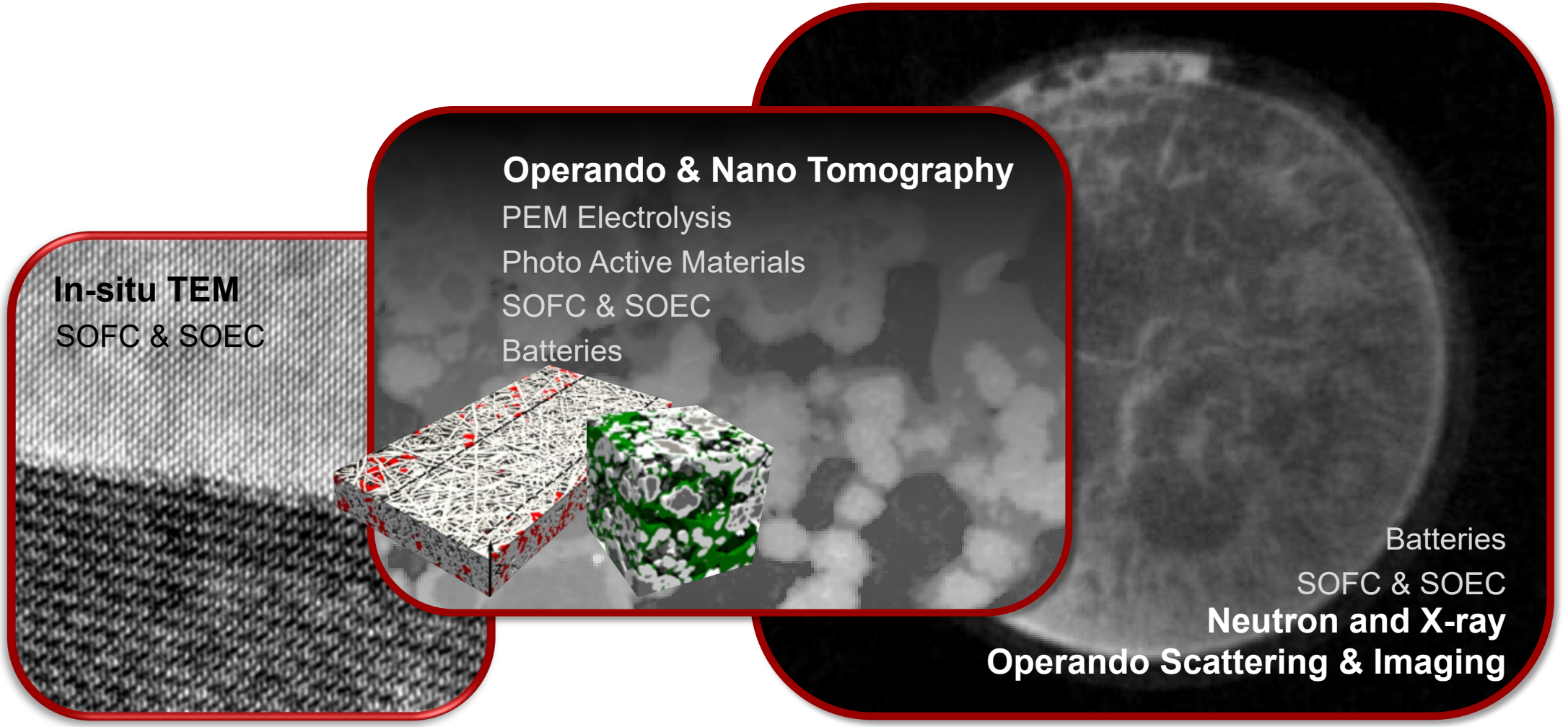
Luise Theil Kuhn, Professor
DTU Energy
Head of Section (*Imaging and Structural Analysis*)

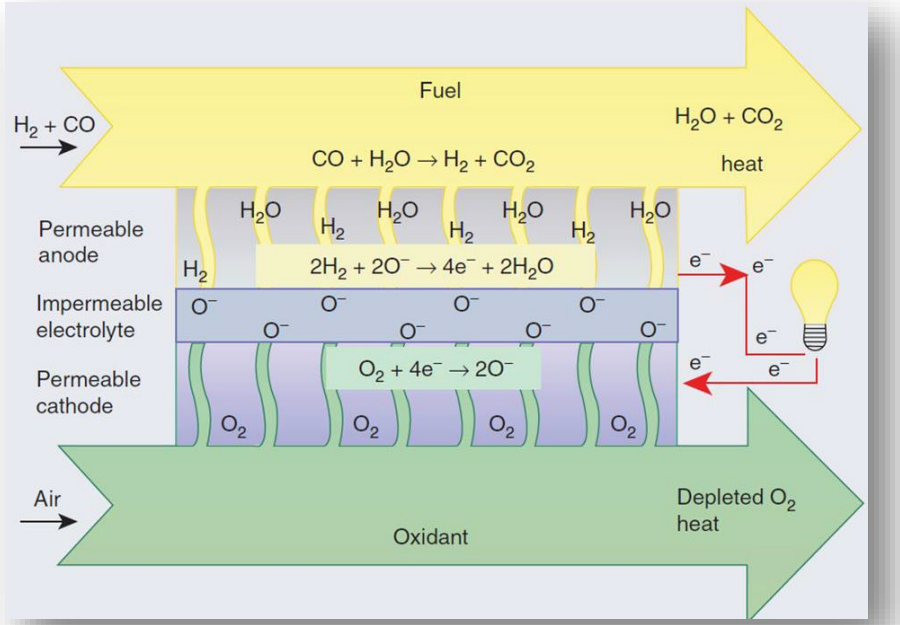
Power-to-X; Observing Energy Conversion Live

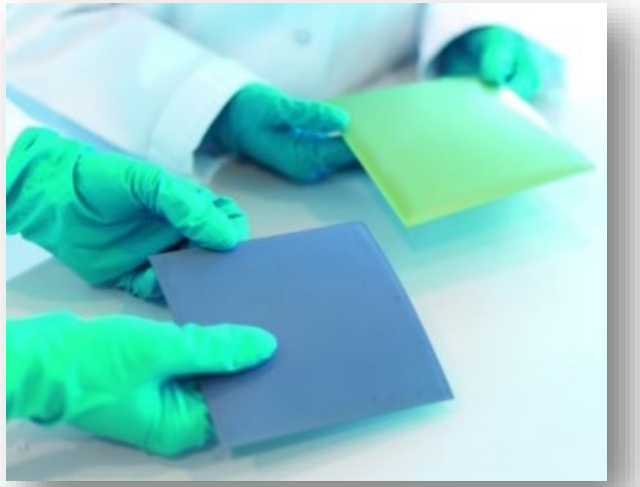
Power - to - X

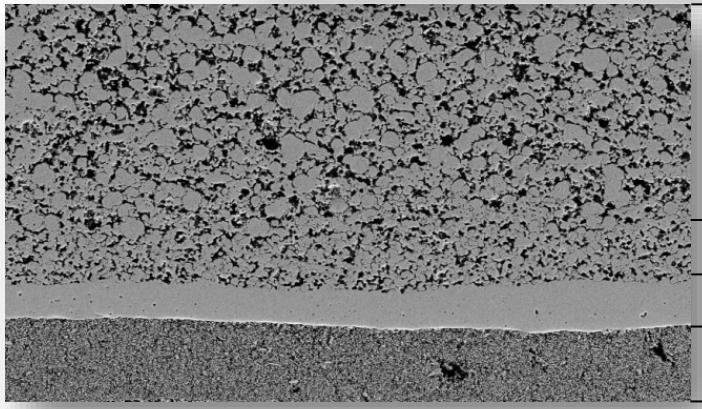
Multi-scale multi-modal in situ characterization



Solid Oxide Electrochemical Cell (SOFC/SOEC)





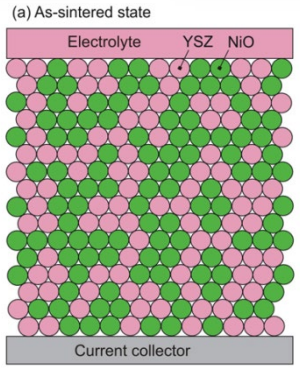


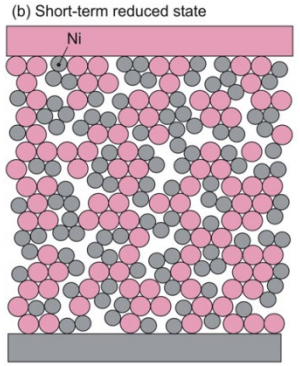
Ni+YSZ support

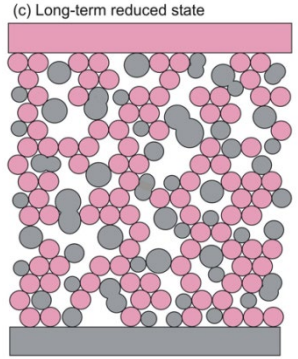
Ni+YSZ
YSZ

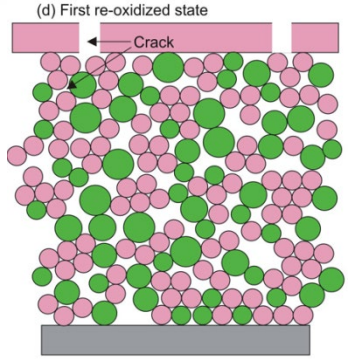
LSM+YSZ

Anne Hauch DTU Energy

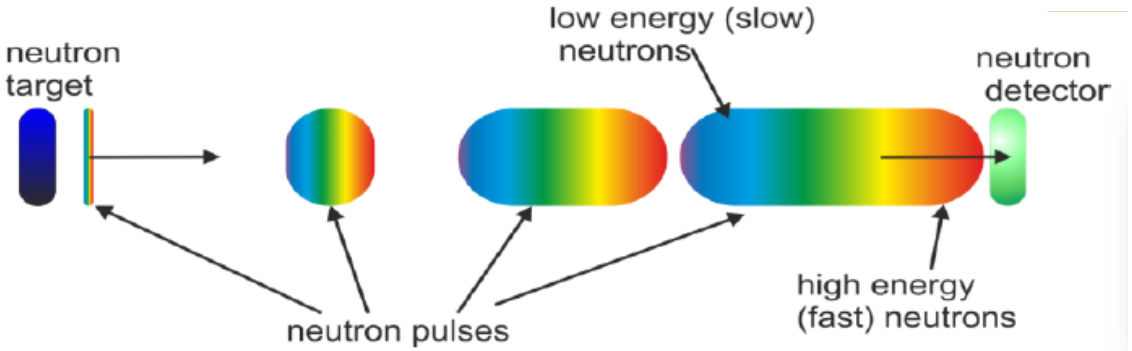




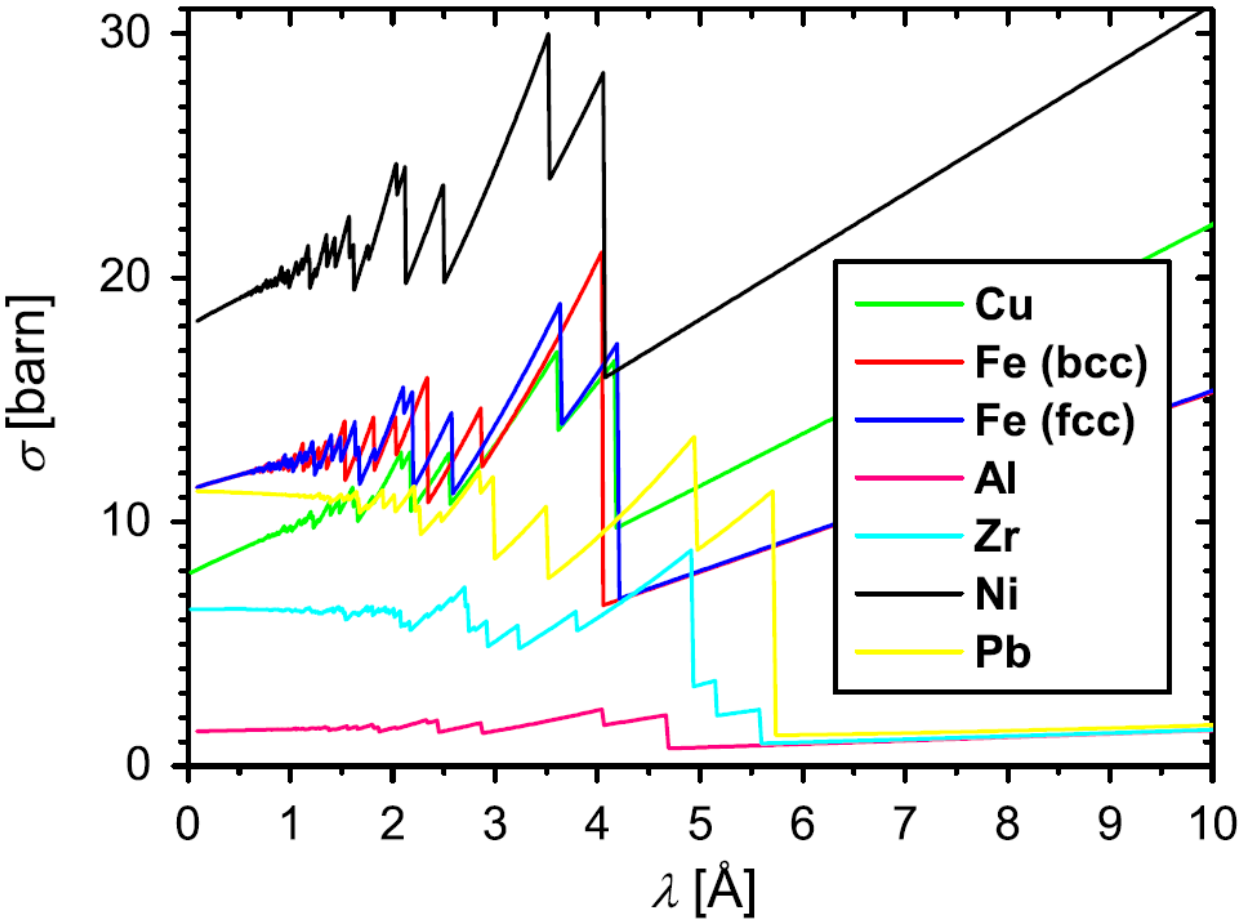




Energy-resolved neutron imaging
Bragg-edge imaging

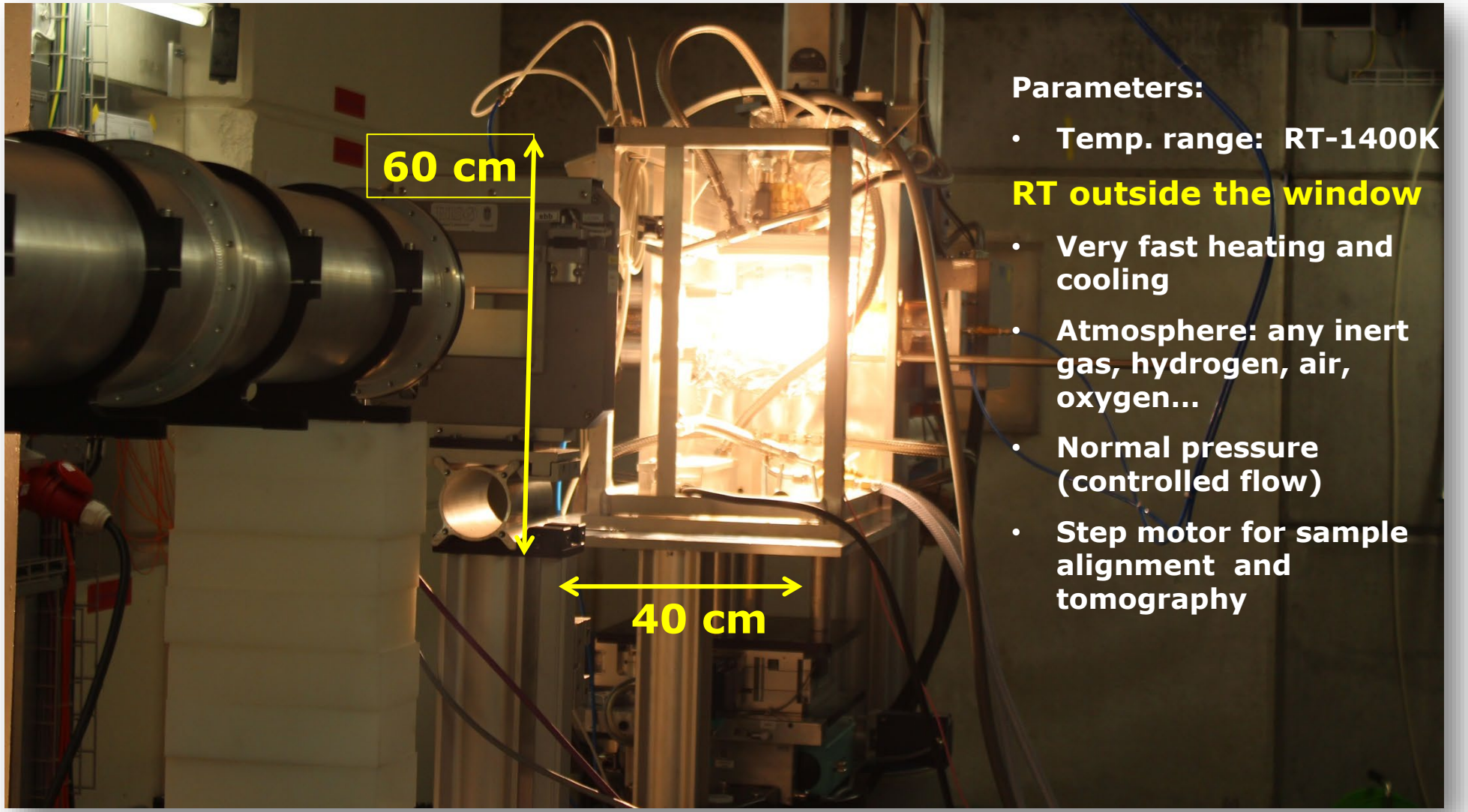


Total neutron cross section for different polycrystalline materials



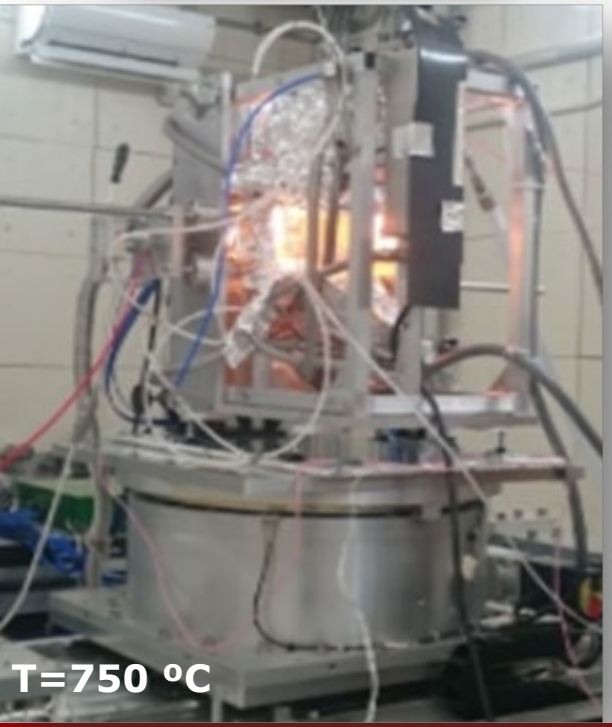
Josic, L. et al (2011). *Nucl. Instruments Methods Phys. Res.* **651**, 166.

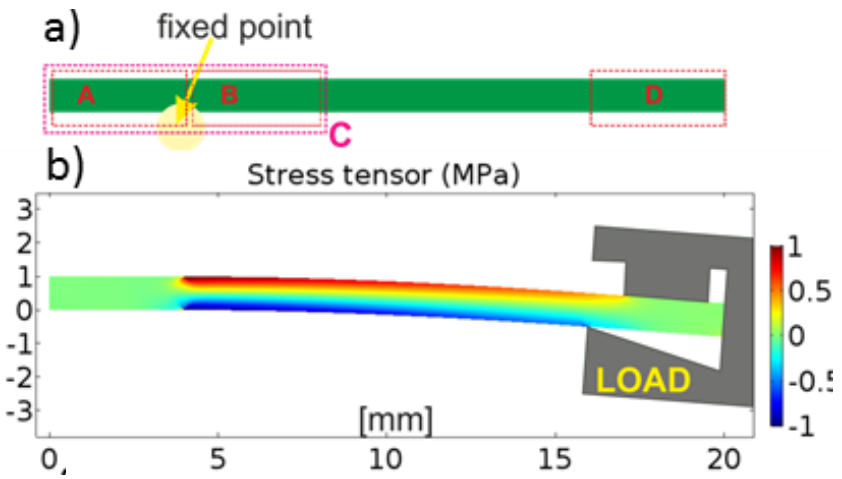
Furnace for redox-cycling and neutron imaging

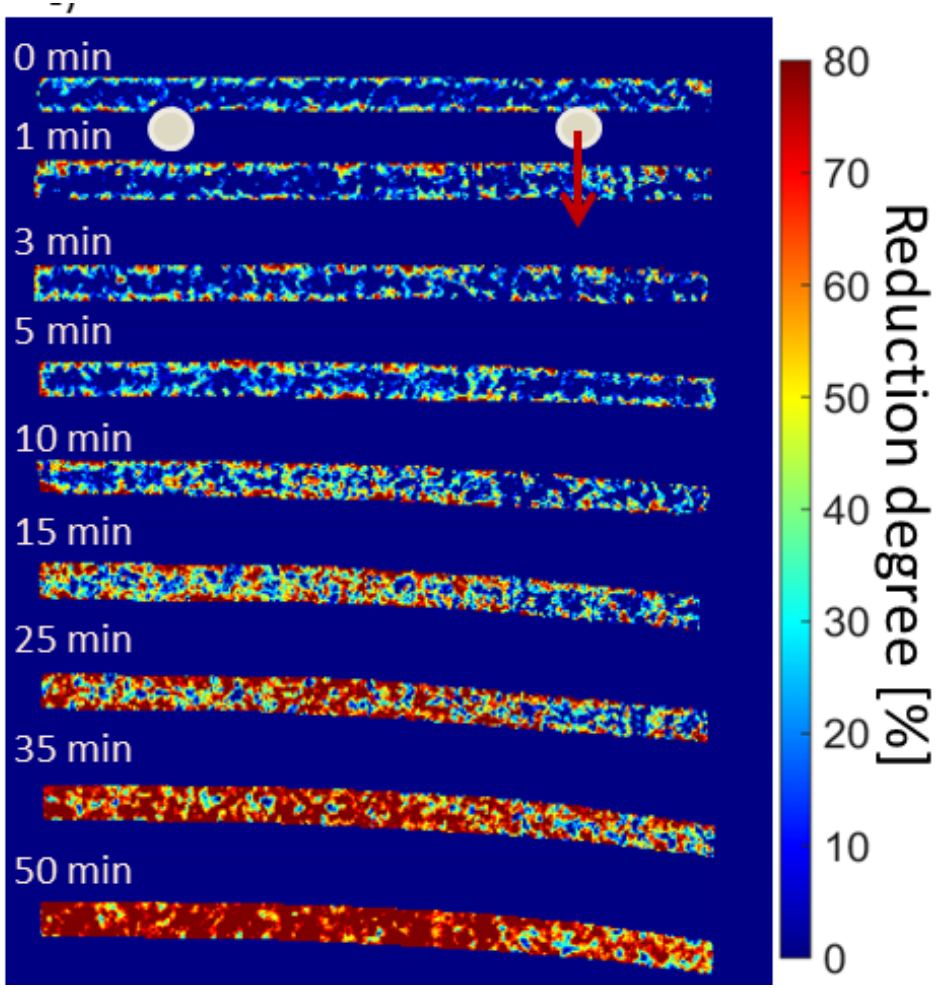


M. Makowska et al. Rev. Sci. Instrum. **86,** *125109 (2015)*

In situ Bragg-edge imaging linking strain and NiO reduction in Solid Oxide Fuel/ Electrolysis Cell electrodes





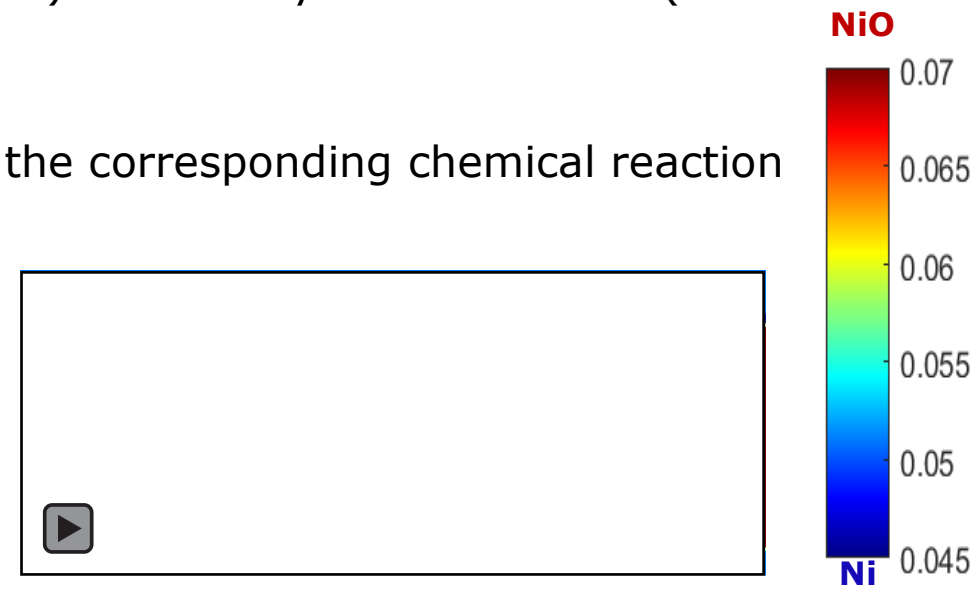


M. Makowska et al, J.Appl.Cryst. **48**, *401(2015)*

M. Makowska et al, J. Appl. Cryst. **49**, *1674 (2016)*

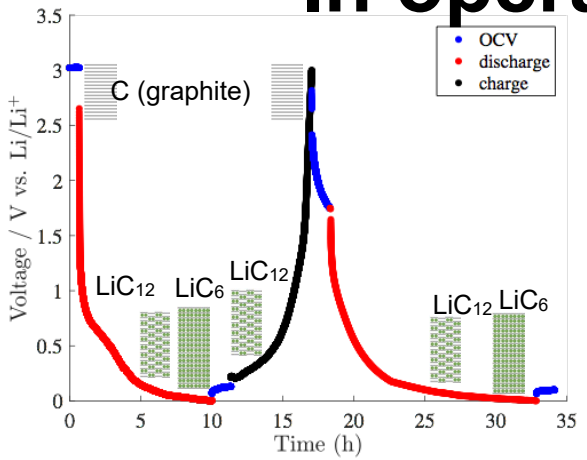
Conclusions on Solid Oxide Electrochemical Cell electrode

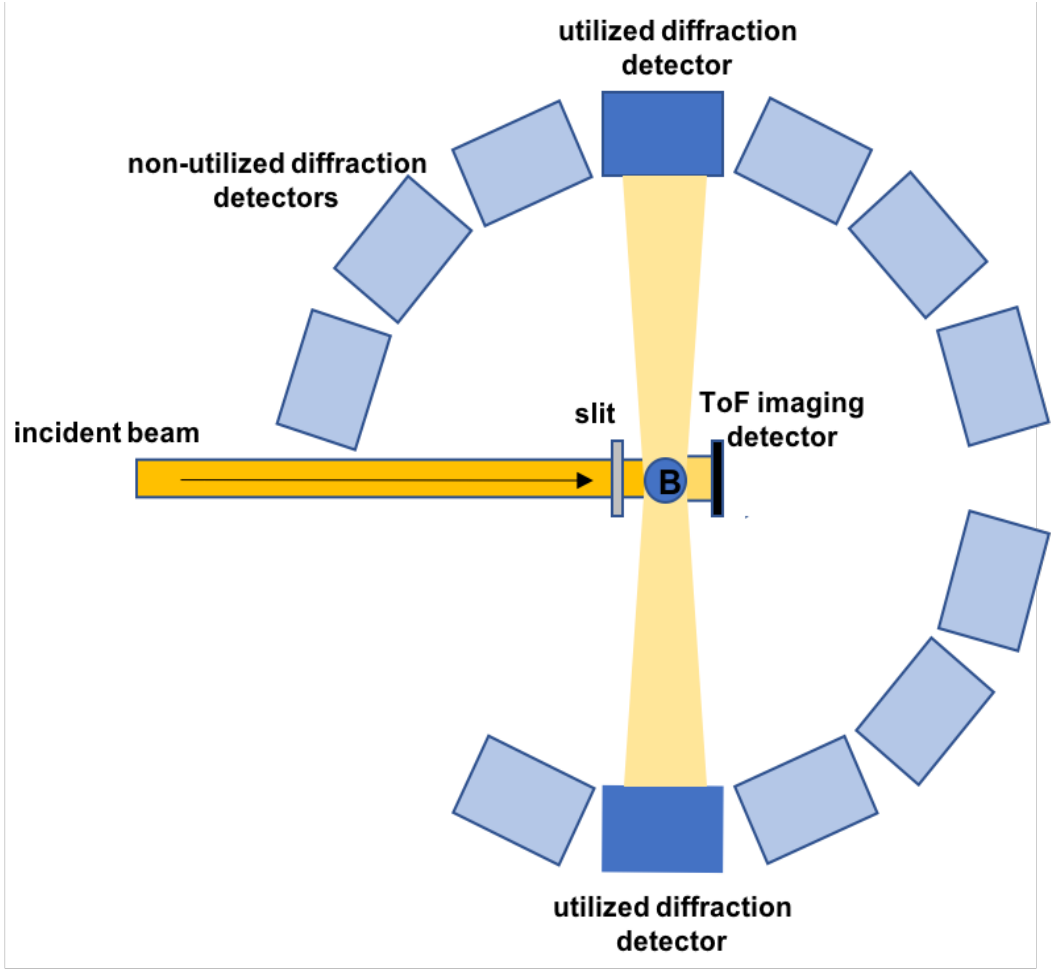
- Reduction process in NiO-YSZ is accelerated by stress
- Accelerated creep occurs also during oxidation!
- Reduction takes place in the whole volume of the investigated material, while re-oxidation takes place easily at the surface (reduction is faster than re-oxidation) and slowly in the volume (clear "oxidation front" can be determined)
- Speed of deformation due to the accelerated creep depends on the corresponding chemical reaction rate
- Company decided for a change in design of their electrodes



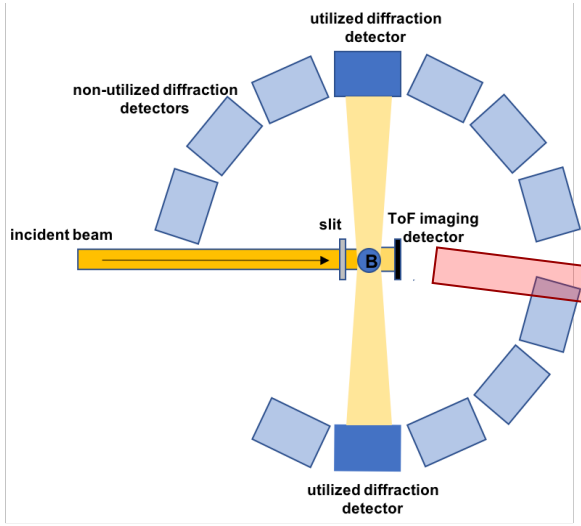
M. Makowska et al, *J. Power Sources* **340**, *167 (2017)*

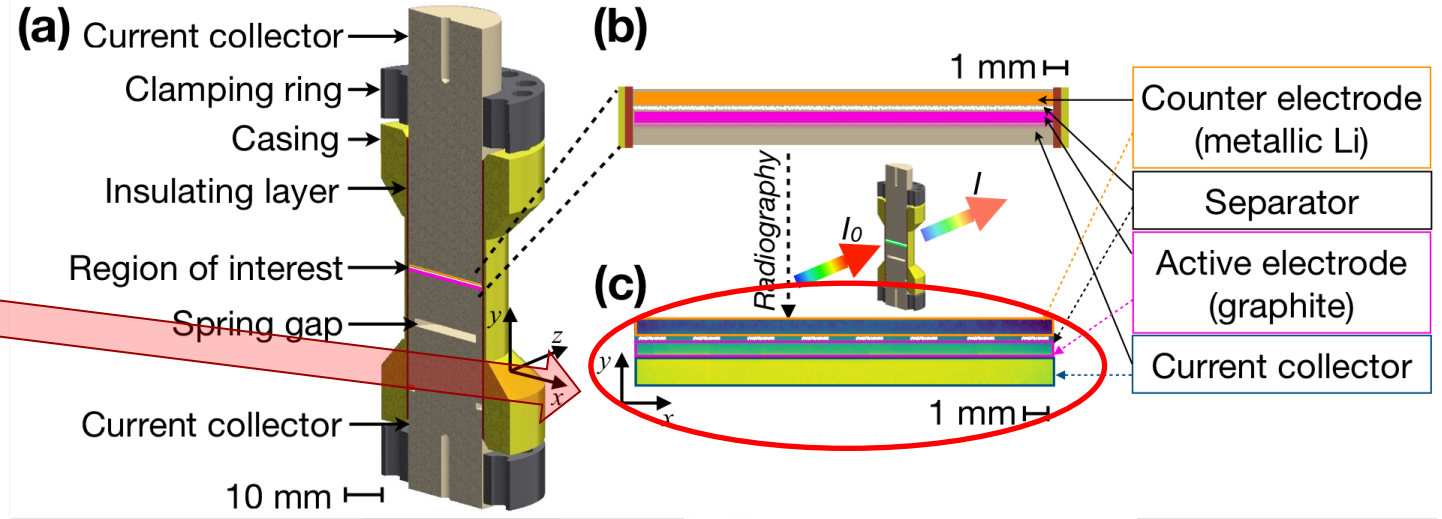
Li-ion transport in a model battery cell
In operando imaging and diffraction simultaneously

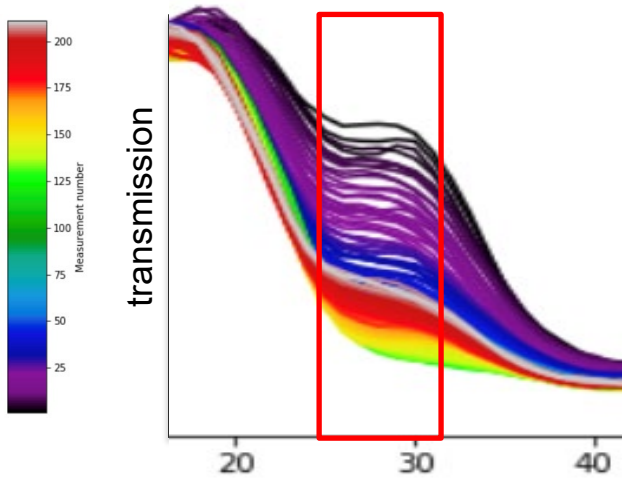




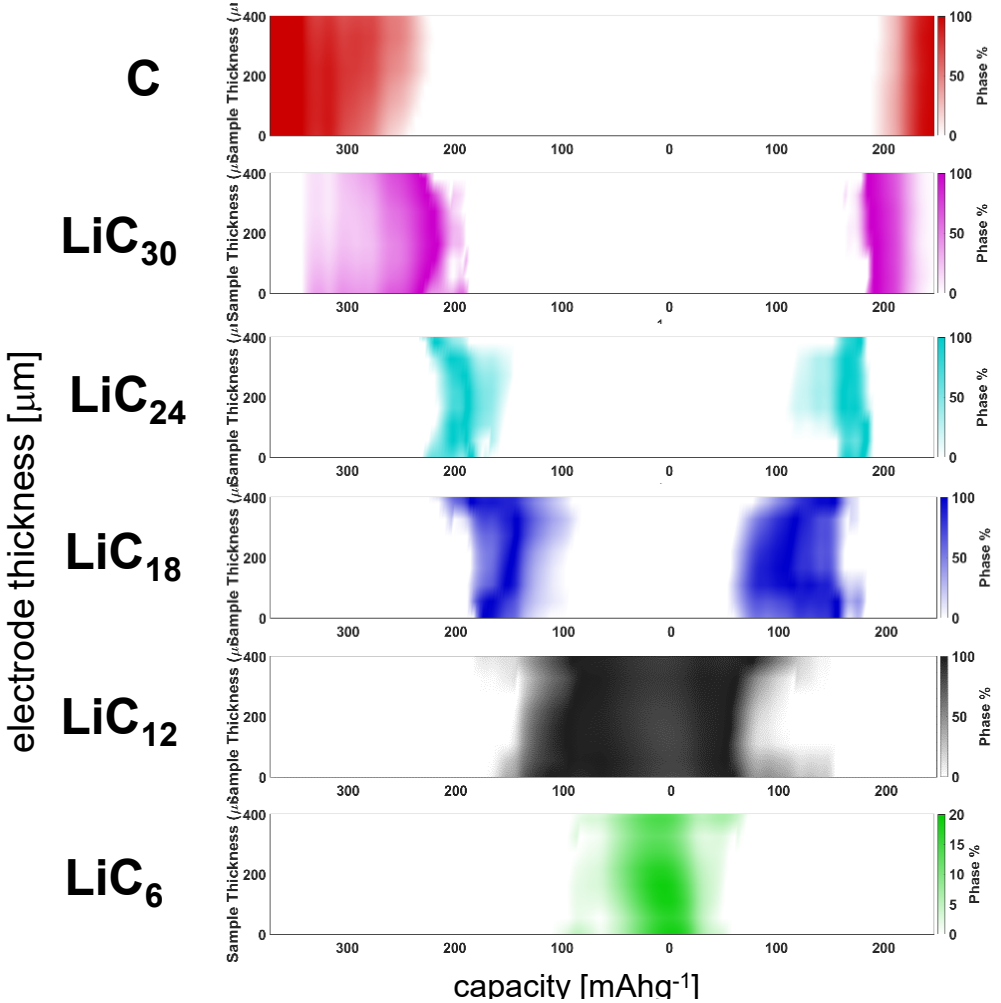
Li-ion transport in a model battery cell
In operando imaging and diffraction simultaneously

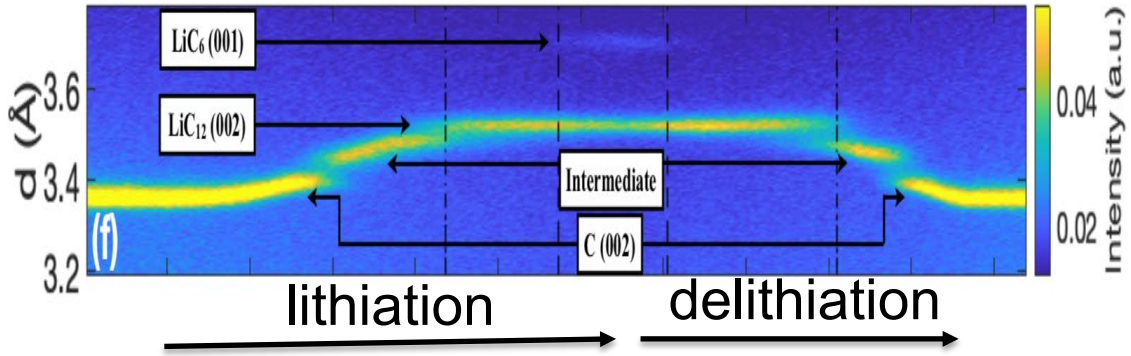


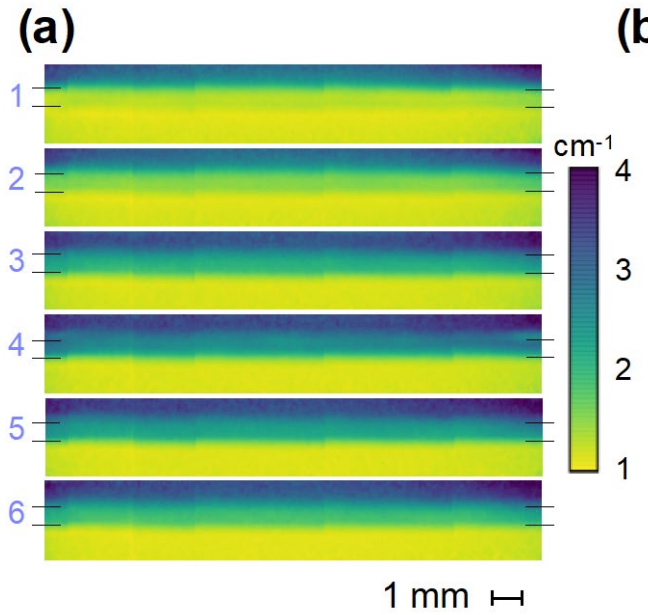


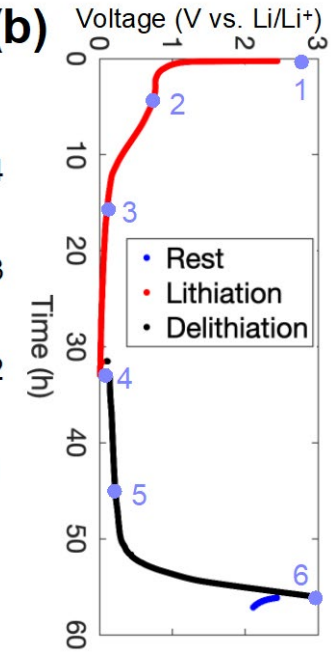


Li-ion transport in a model battery cell
In operando imaging and diffraction simultaneously









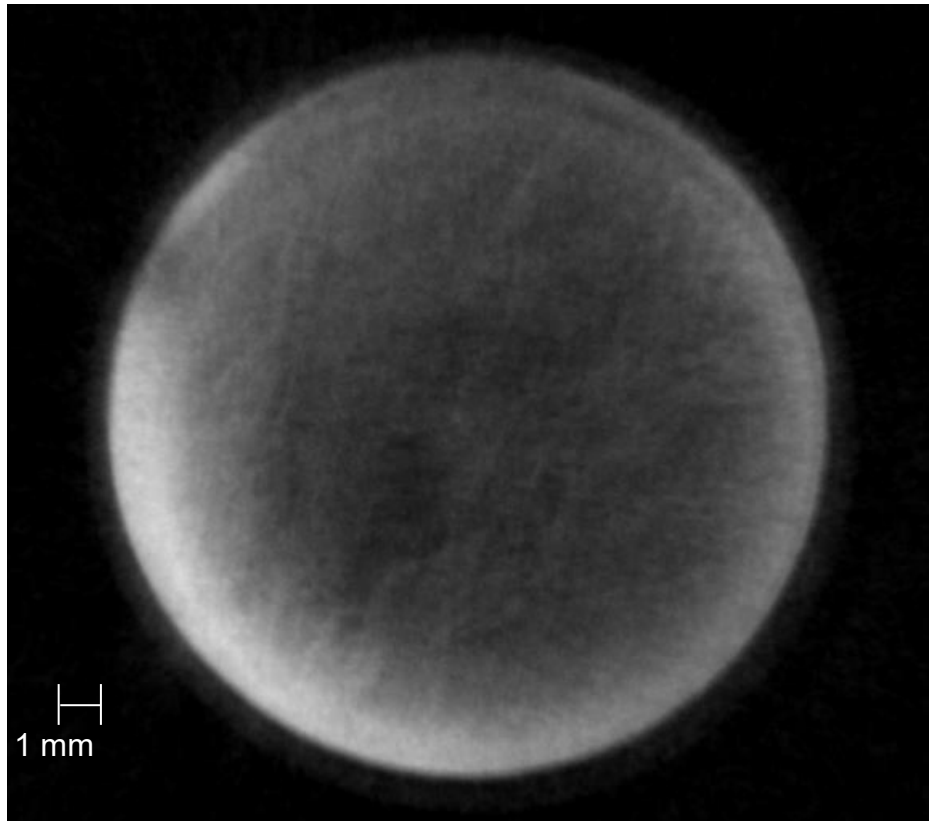
M. Lacatusu et al, manuscript in preparation

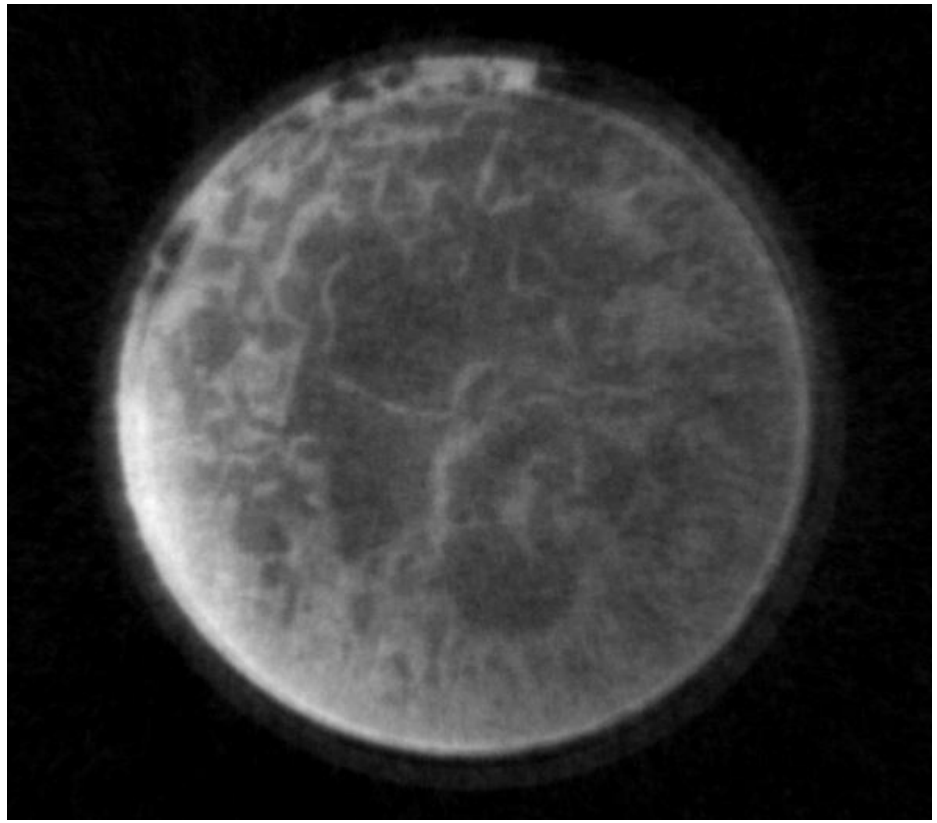
Hot topic: Na-ion batteries

Pristine Na-ion battery

Slice 533

After 500 charge-discharge cycles



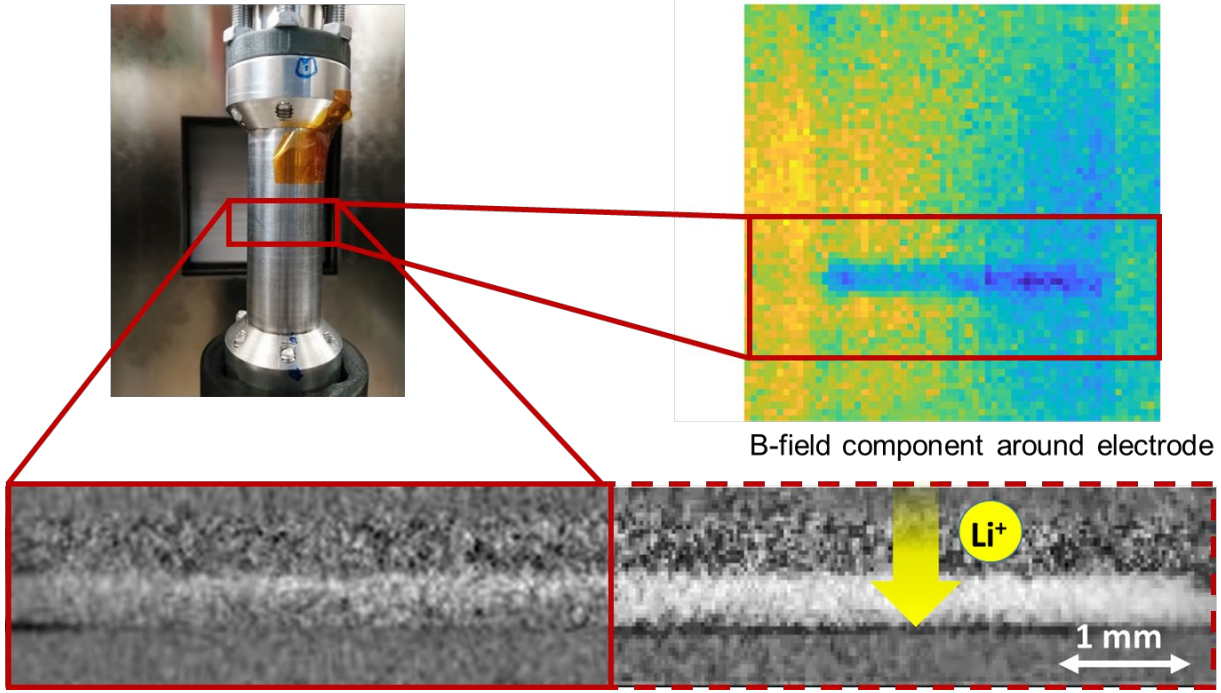


Perspectives: Polarized neutron imaging of magnetic fields and current distributions

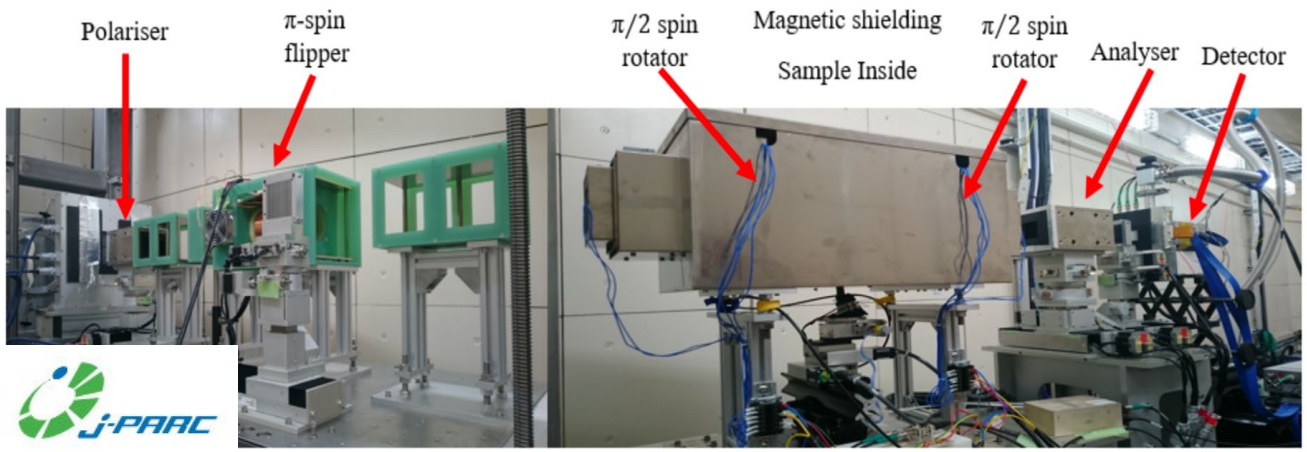
Link current distribution to Bragg-edge data in each pixel

Link to diffraction in 3D

Map in 3D

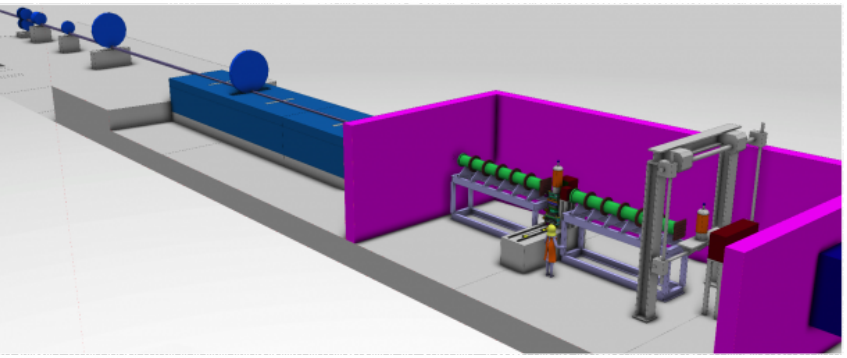


M. Lacatusu, PhD thesis, 2020



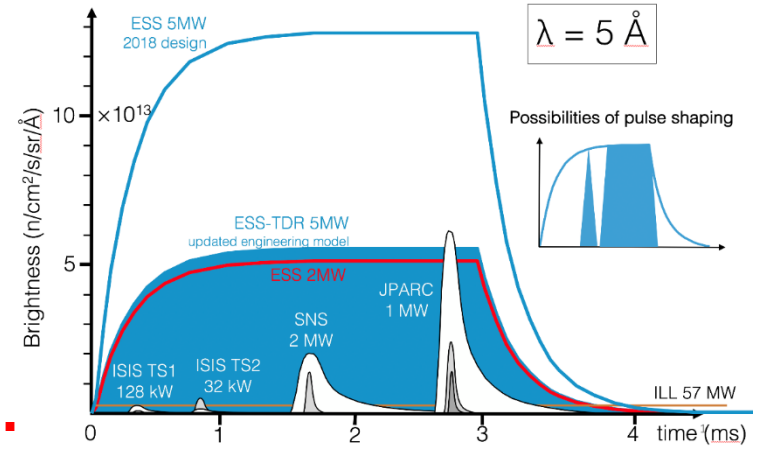
M. Sales et al, Scientific Reports, vol: 8, issue: 1, pages: 1-6, 2018

Energy-resolved neutron imaging and diffraction @ ESS: ODIN and BEER



ESS will make possible:

Flux and timescale relevant for real operando studies aplying the low-intensity/contrast methods bringing us far beyond ”nice images”.



Observing energy conversion live.

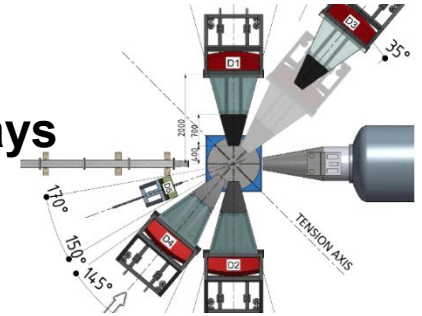
Bragg-edge imaging

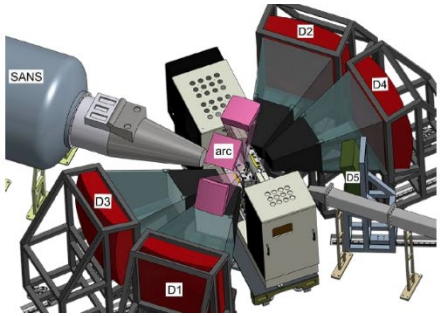
3D imaging and diffraction

Phase contrast imaging

Polarized imaging

Simultaneously imaging with X-rays





Optical and Diffraction Imaging with Neutrons ODIN Beamline for European materials Engineering Research - BEER

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Rioji Kiyanagi

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SOLID Hard materials in 3D

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Nancy Elewa

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Öresund-Kattegat-Skagerrak
ESS & MAX IV: Cross Border Science and Society
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European Union
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