ThermoFisher SCIENTIFIC

3D characterization at every length scale

10. – 12. September

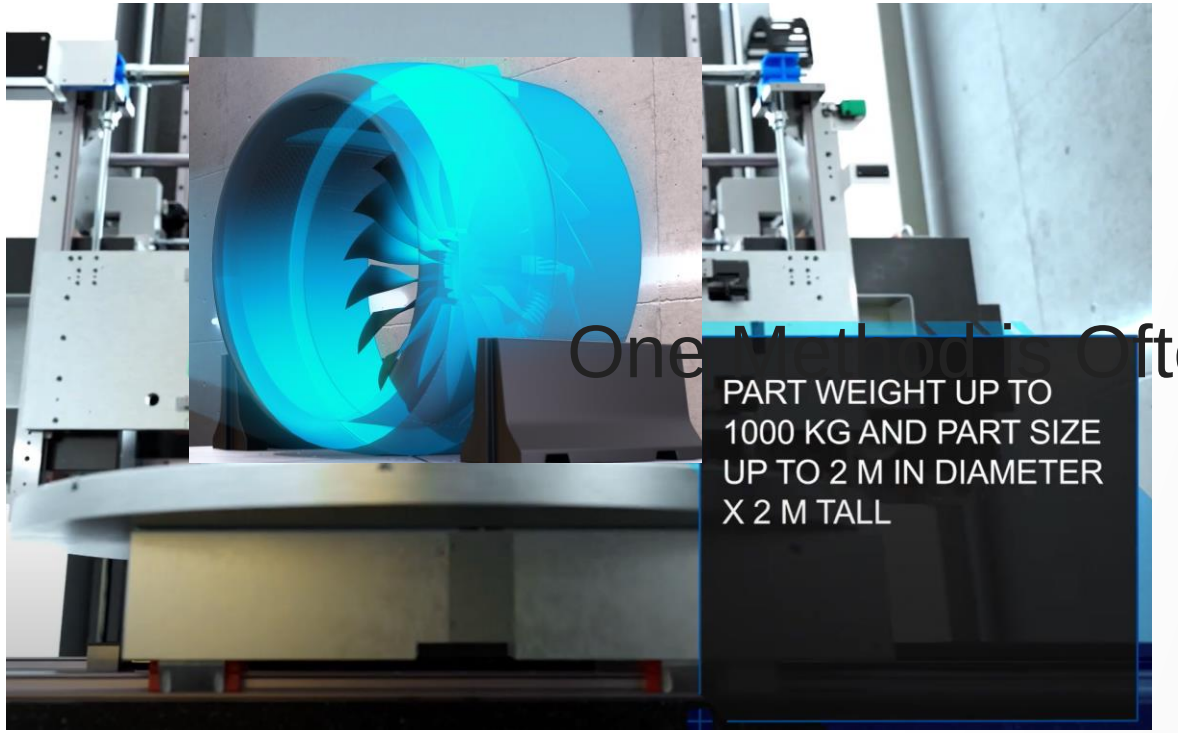
Hamburg

Arno Meingast
Business Development Manager for Clean Energy DACH

The world leader in serving science

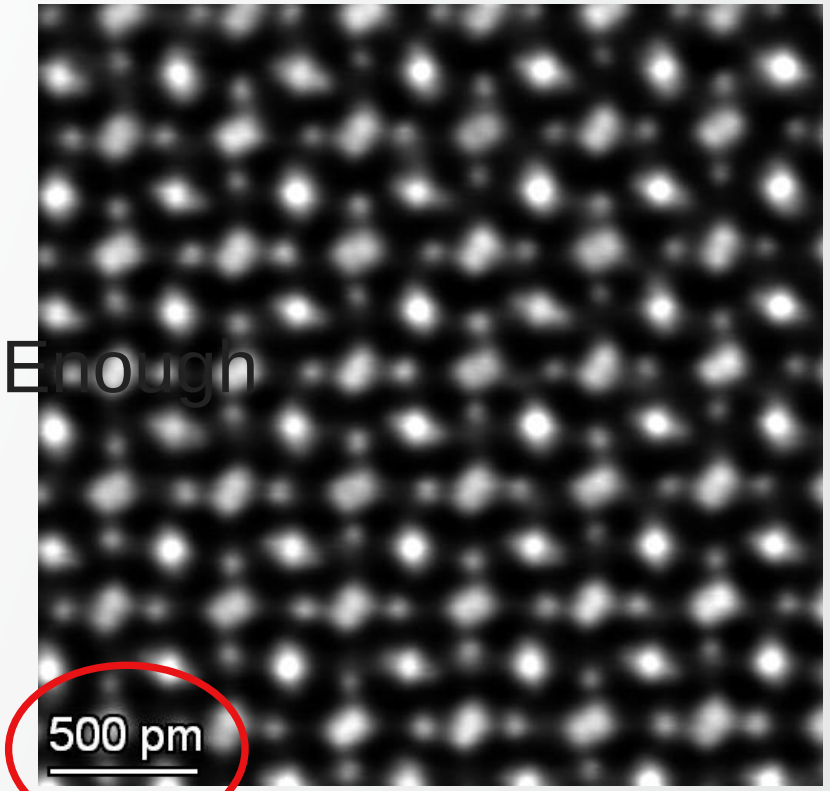
Why is Microscale Analysis Important?

I need to analyze large parts… **AND** I need to visualize small features…



Waygate Technologies | High-Energy CT
Phoenix Power|scan HE

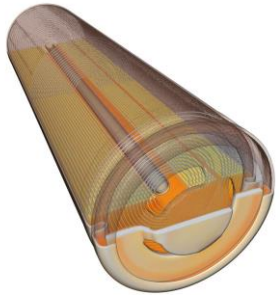
One Method is Often Not Enough

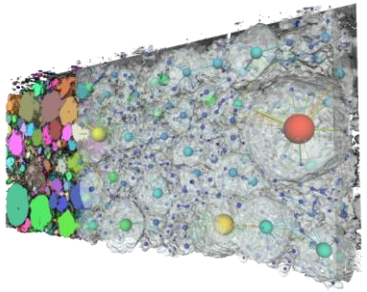


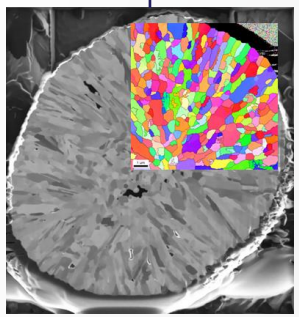
Spectra 300 Scanning Transmission Electron Microscope (S/TEM)

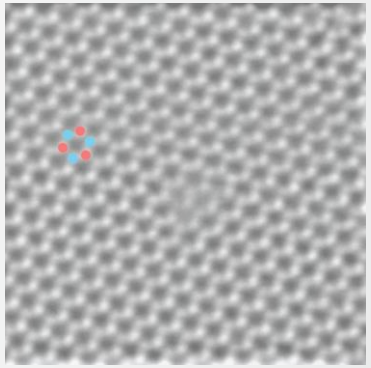
Thermo Fisher Scientific MSD/EM Portfolio

SEM/DualBeam







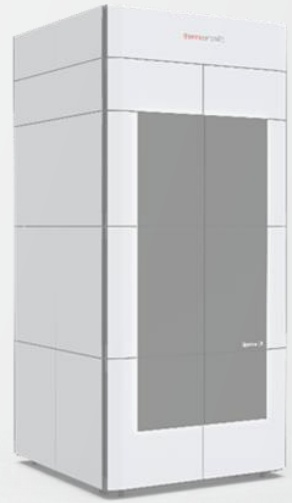


(micro/nano) CT | SEM | DualBeam | TEM

Waygate Technologies

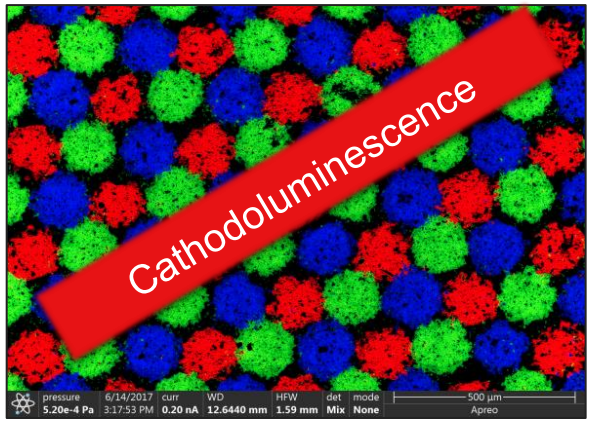
Axia, Apreo 2
Phenom Desktop

Scios 2
Helios 5 PFIB (Laser)

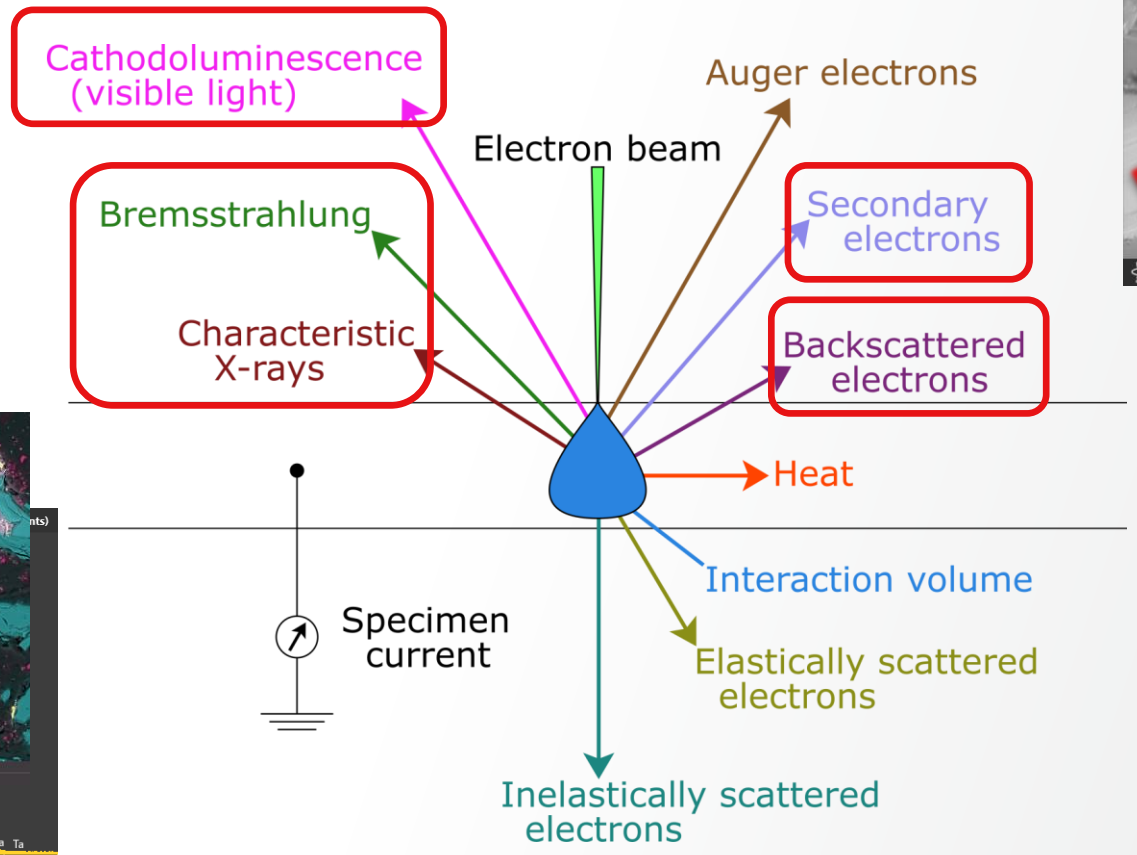


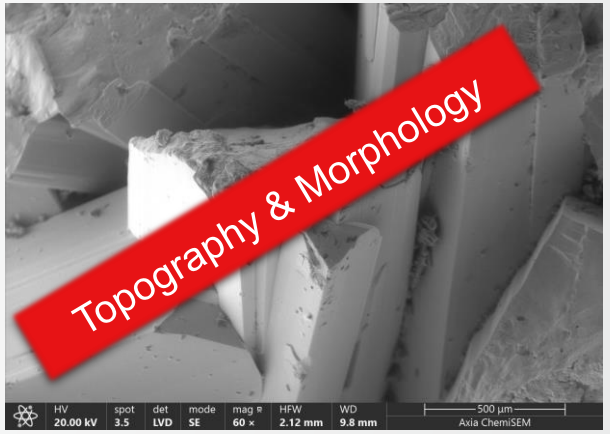
Talos
Spectra

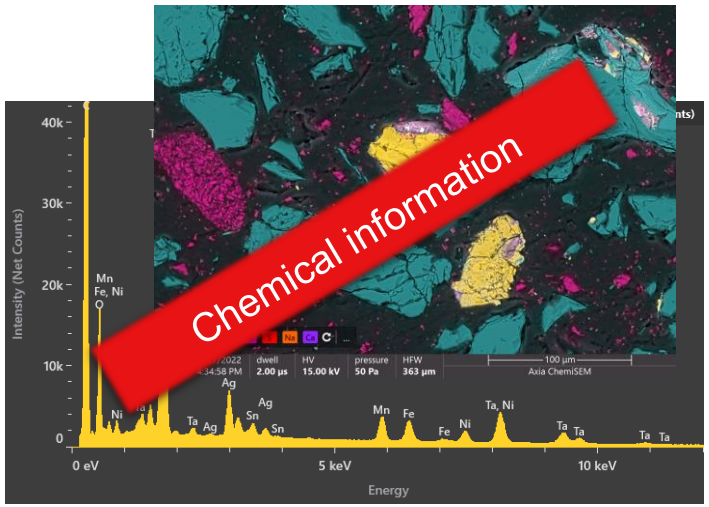
SEM enables a vast variety of information available:

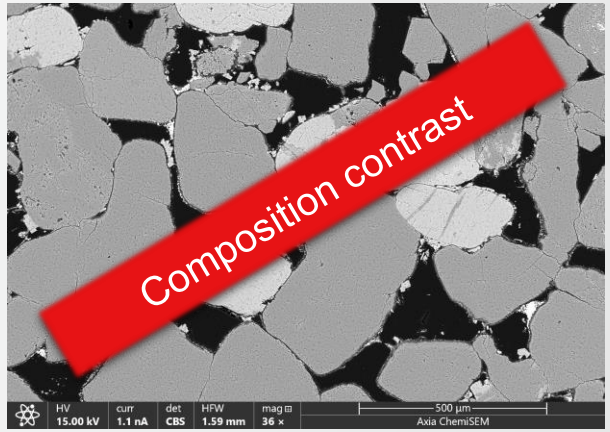


Luminescent materials in a display





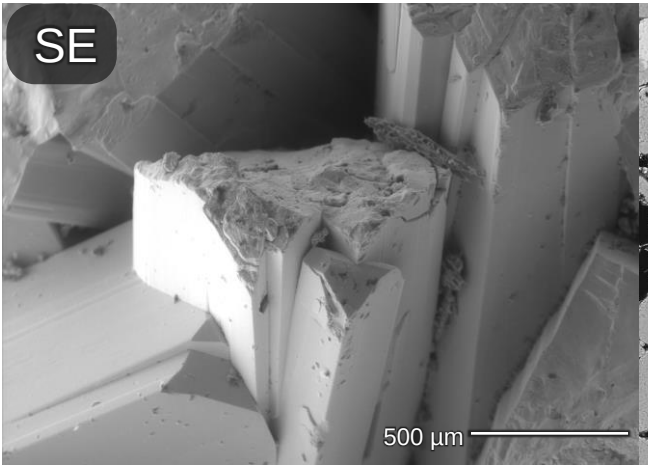


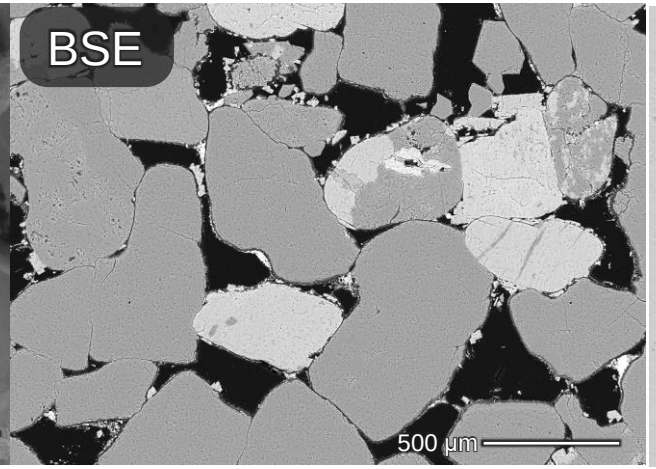


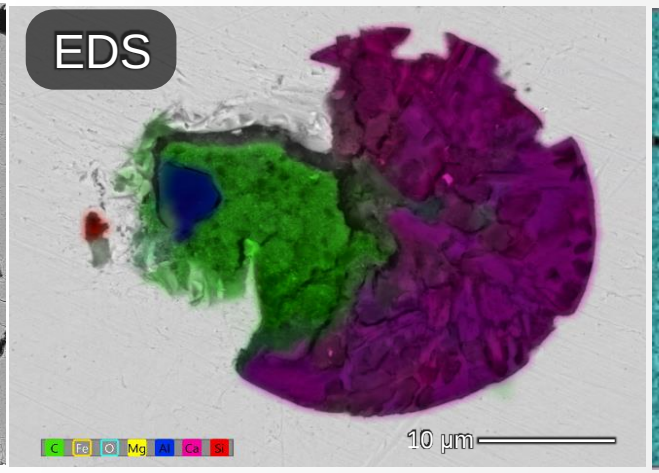
Today, EM is a multimodal instrument that doesn't just “take pictures”.

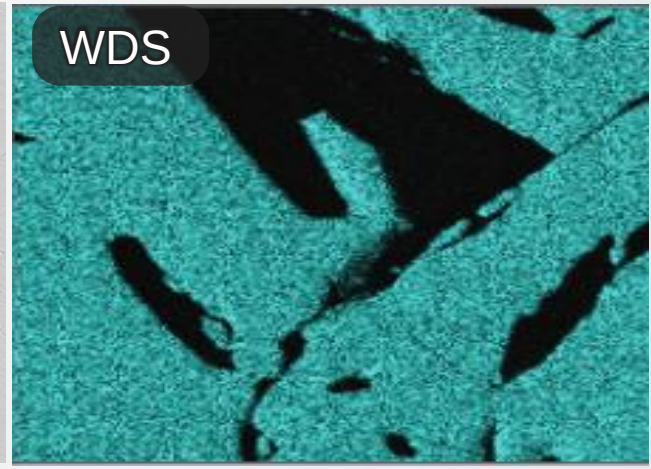
SEM enables a vast variety of information available

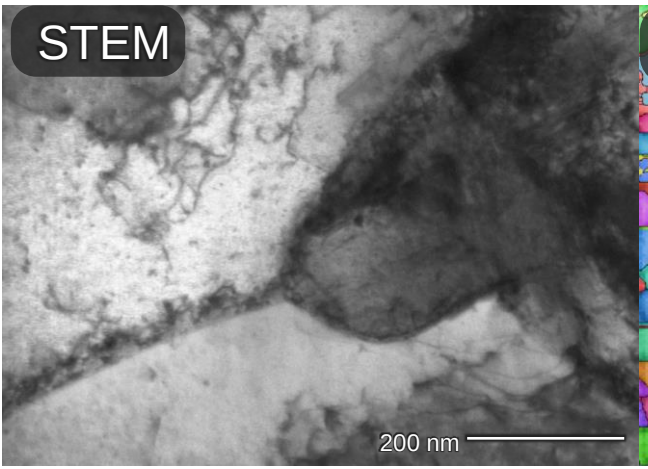
Floor model SEMs allow for a wide variety of information and analysis

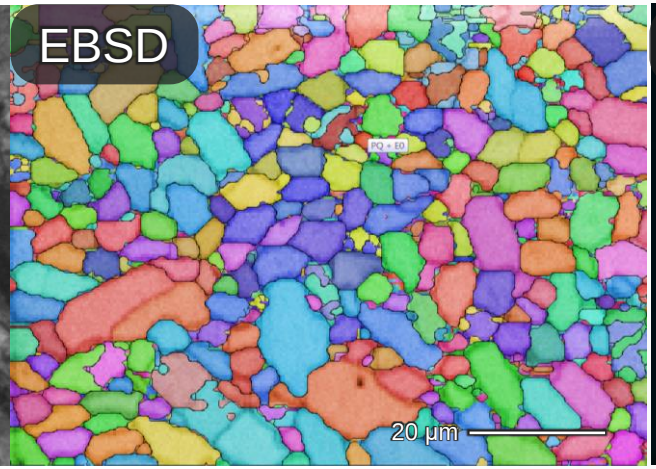


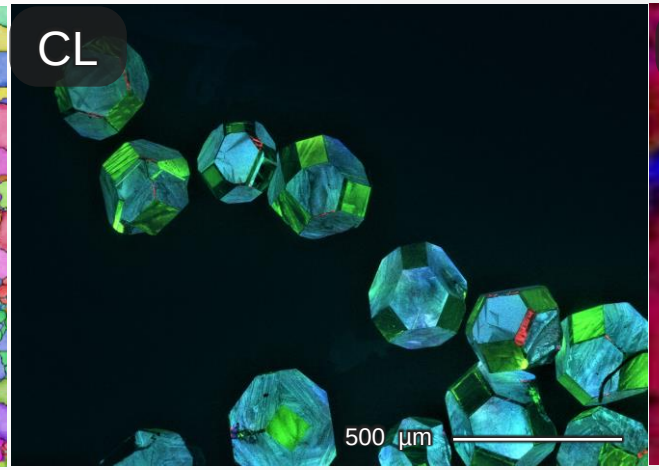


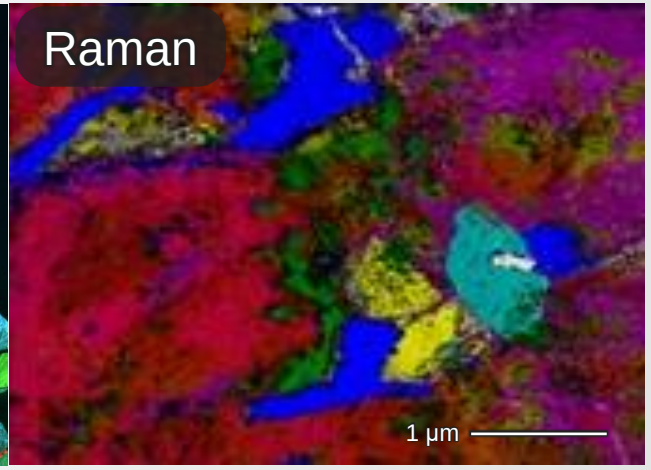




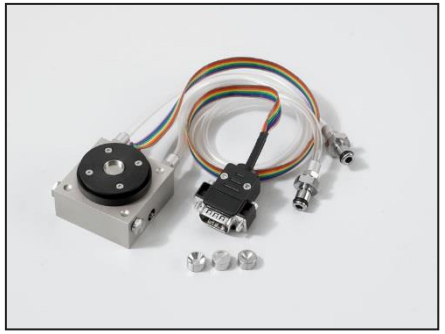






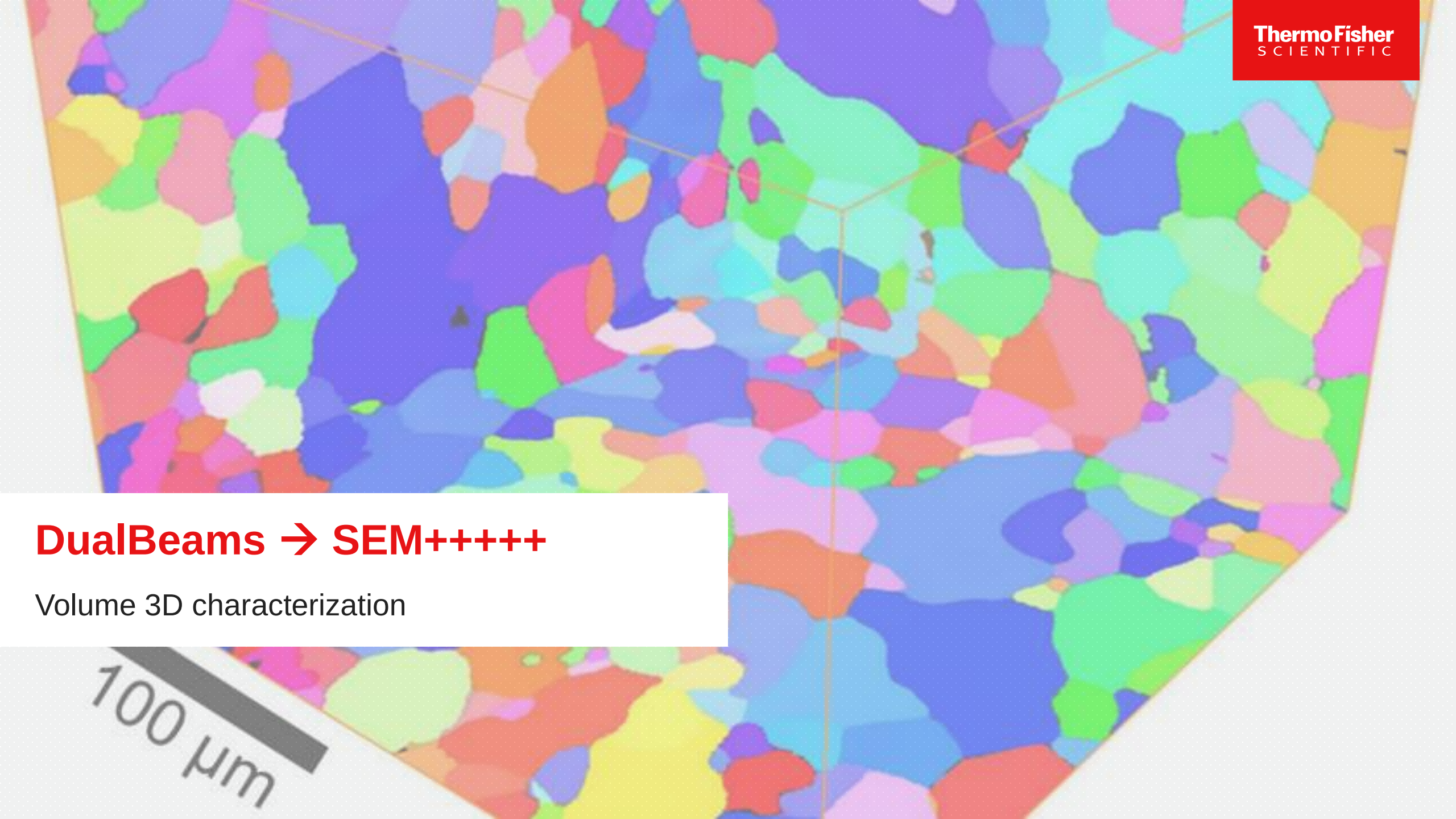


Controlling Sample Humidity – Bulk Samples



Salt crystals dissolving and recrystallizing.
Conditions: 10 kV, GSED detector, sample temperature 2° C, chamber pressure 300 – 620 Pa

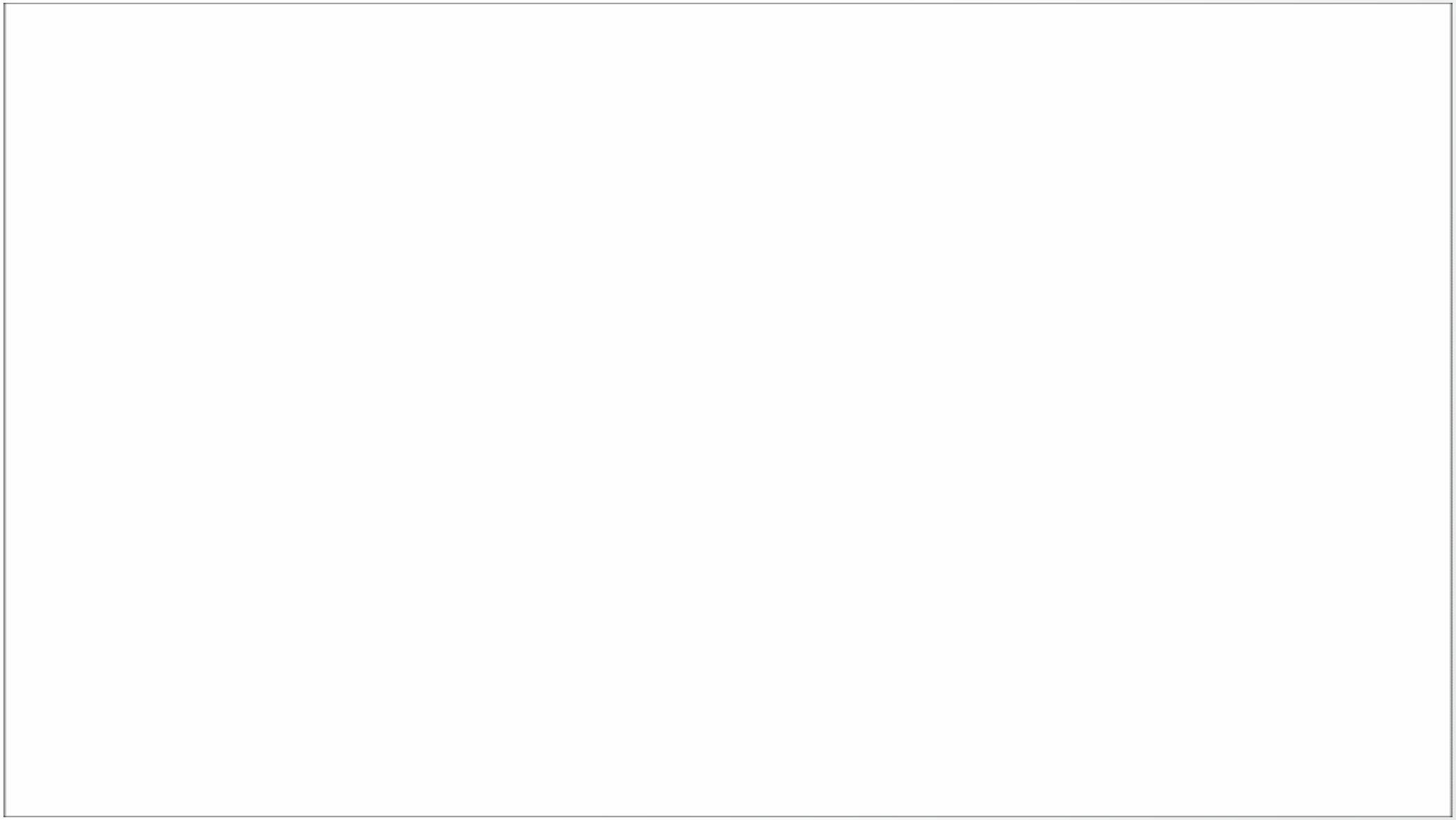
Image courtesy: Yigit Oztan, Eindhoven NanoPort



DualBeams → SEM+++++

Volume 3D characterization

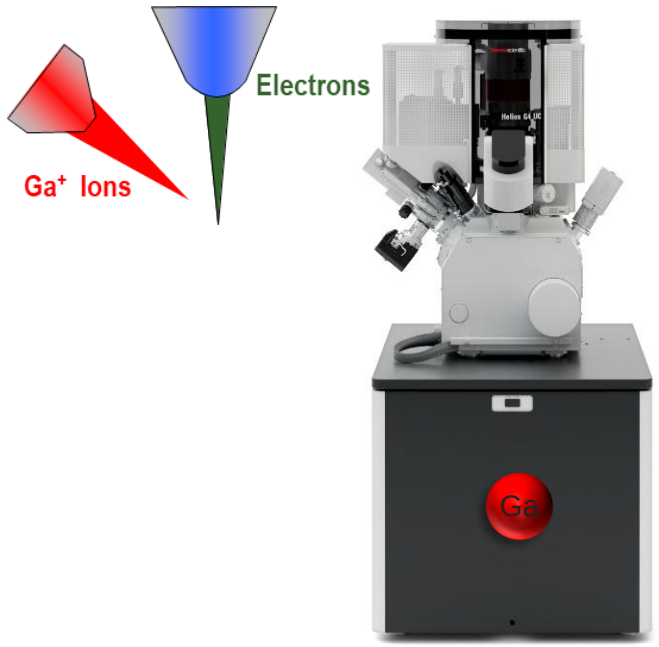
DualBeam for the 3rd dimension: SEM + FIB



DualBeam Technologies

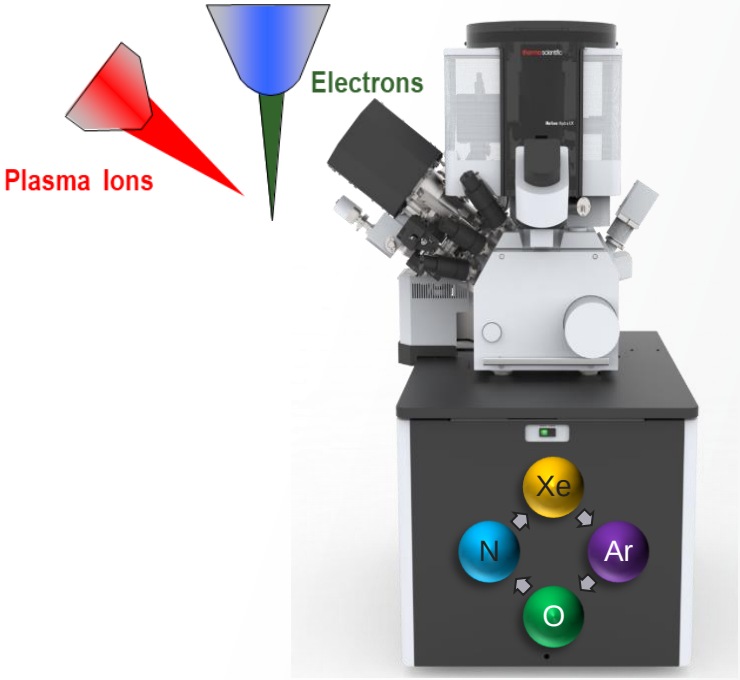
- Different ion sources (incl. laser) to cover wide number of applications in different materials system
- Increasing volume for analysis: Ga^+-FIB → P-FIB → Laser PFIB

Ga^+-FIB



Ga^+ ion source

Plasma-FIB



Plasma ion source (Xe, Ar, N, O)

Laser-PFIB

Femtosecond Laser + Plasma ion source

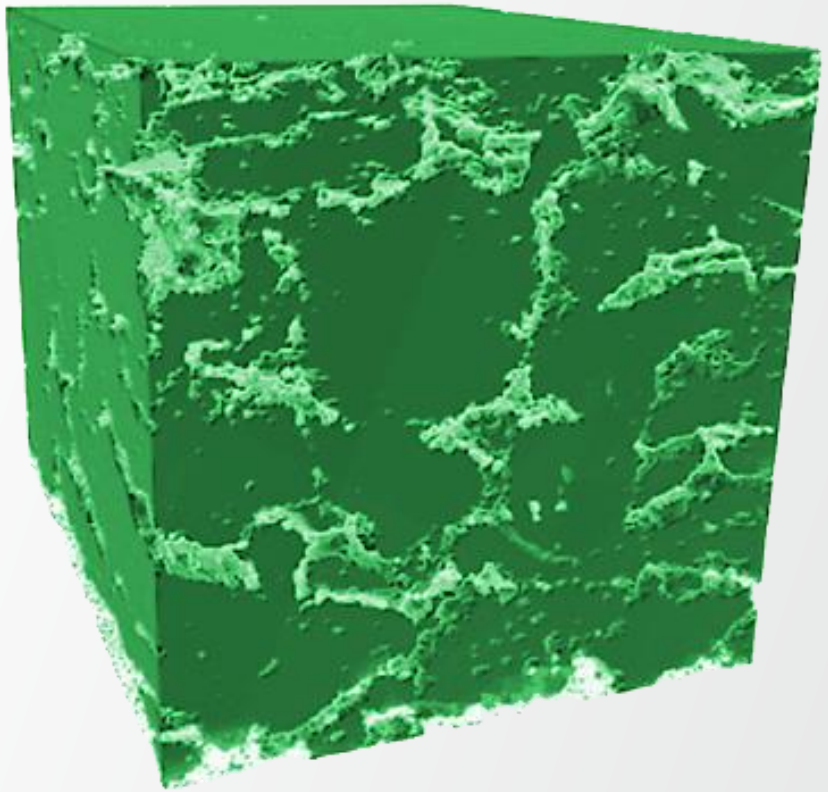
DualBeam Technologies: Analyzed 3D Volume Comparison

3D volumes acquired within the same amount of time with FIB, Plasma FIB, and fs-laser:

Example: Graphite anode (slow to mill with every FIB)

FIB (1x)

PFIB
(~40x)



fs-Laser ~15000x

500 µm

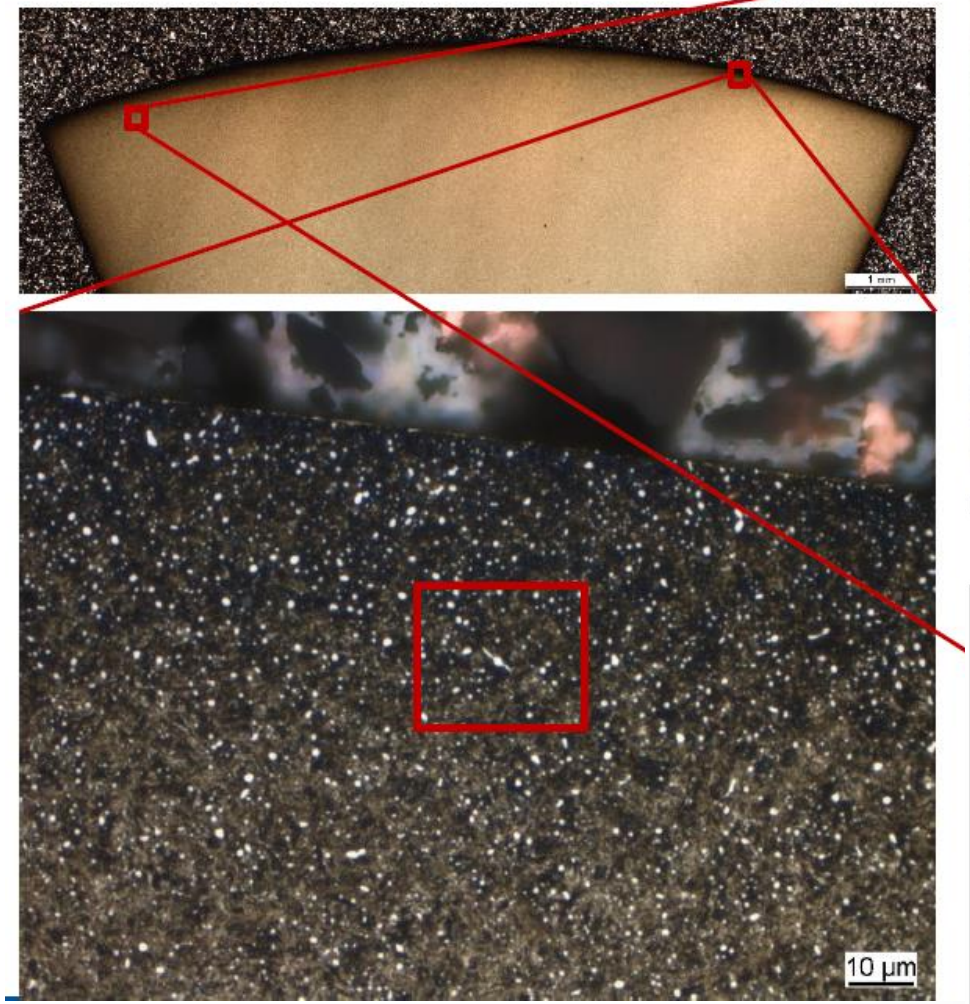
Representative length scale of DualBeam platforms:

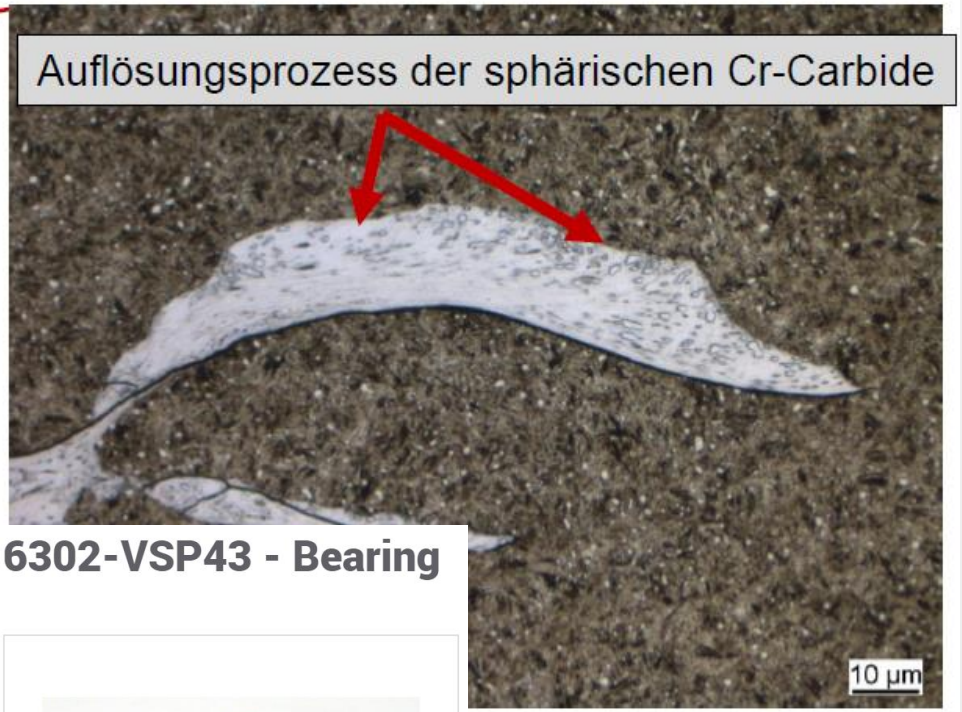
- Ga-FIB: ~ 50 µm
- Plasma-FIB: ~ 50 - 200 µm
- Laser PFIB: 200 µm to mm

Metallographische Untersuchung

Voranalyse für Mikrostrukturuntersuchung - VSP 43 (16_0245)

Metallografischer Schliff

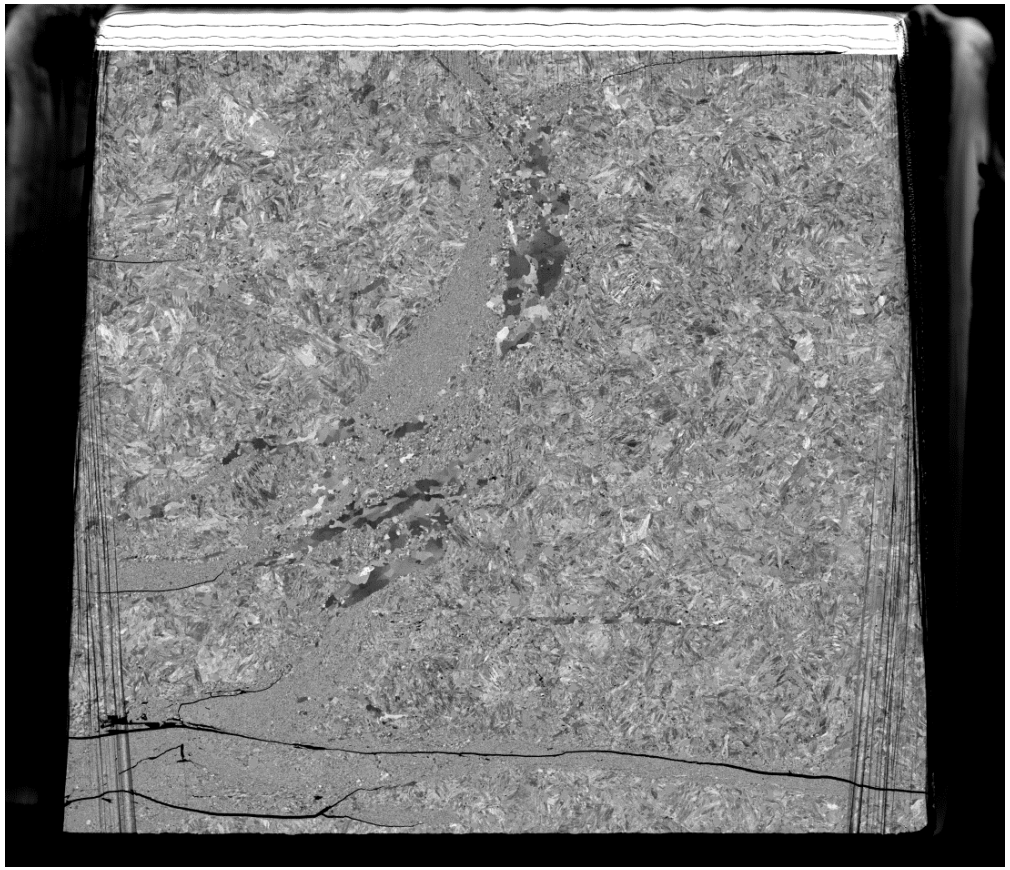




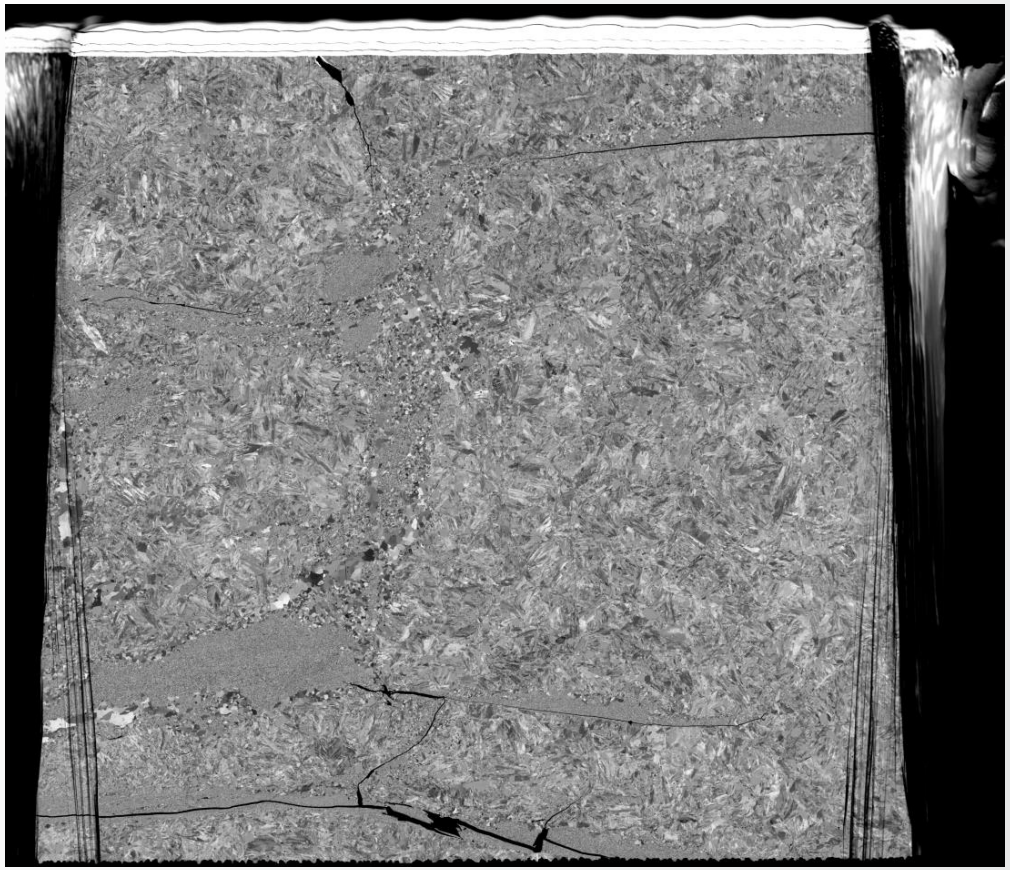
6302-VSP43 - Bearing

GFE – Auto Slice & View Images

[100 nm slice thickness]

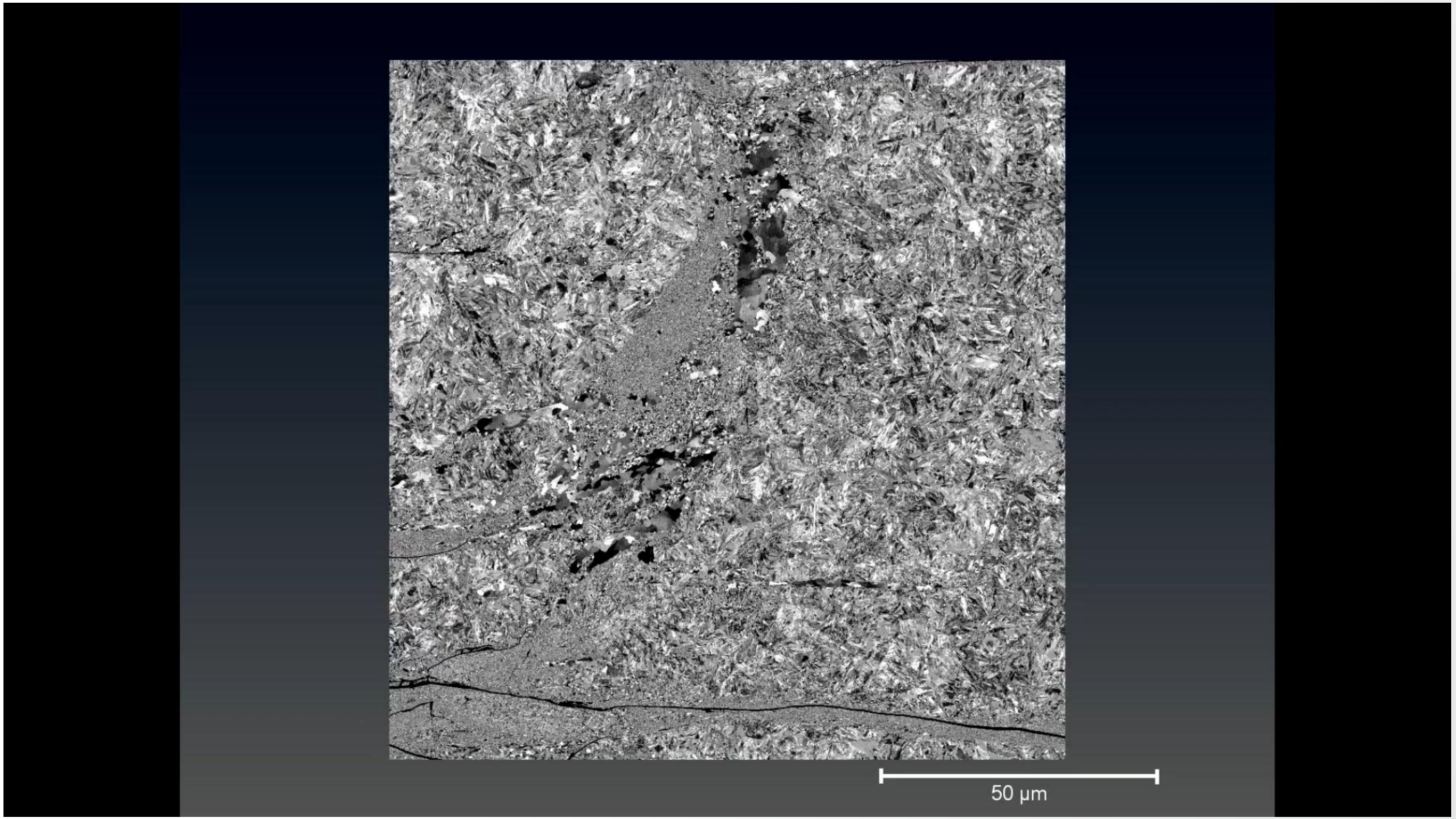


Slice 1



Slice 585

GFE – Segmentation & Animation



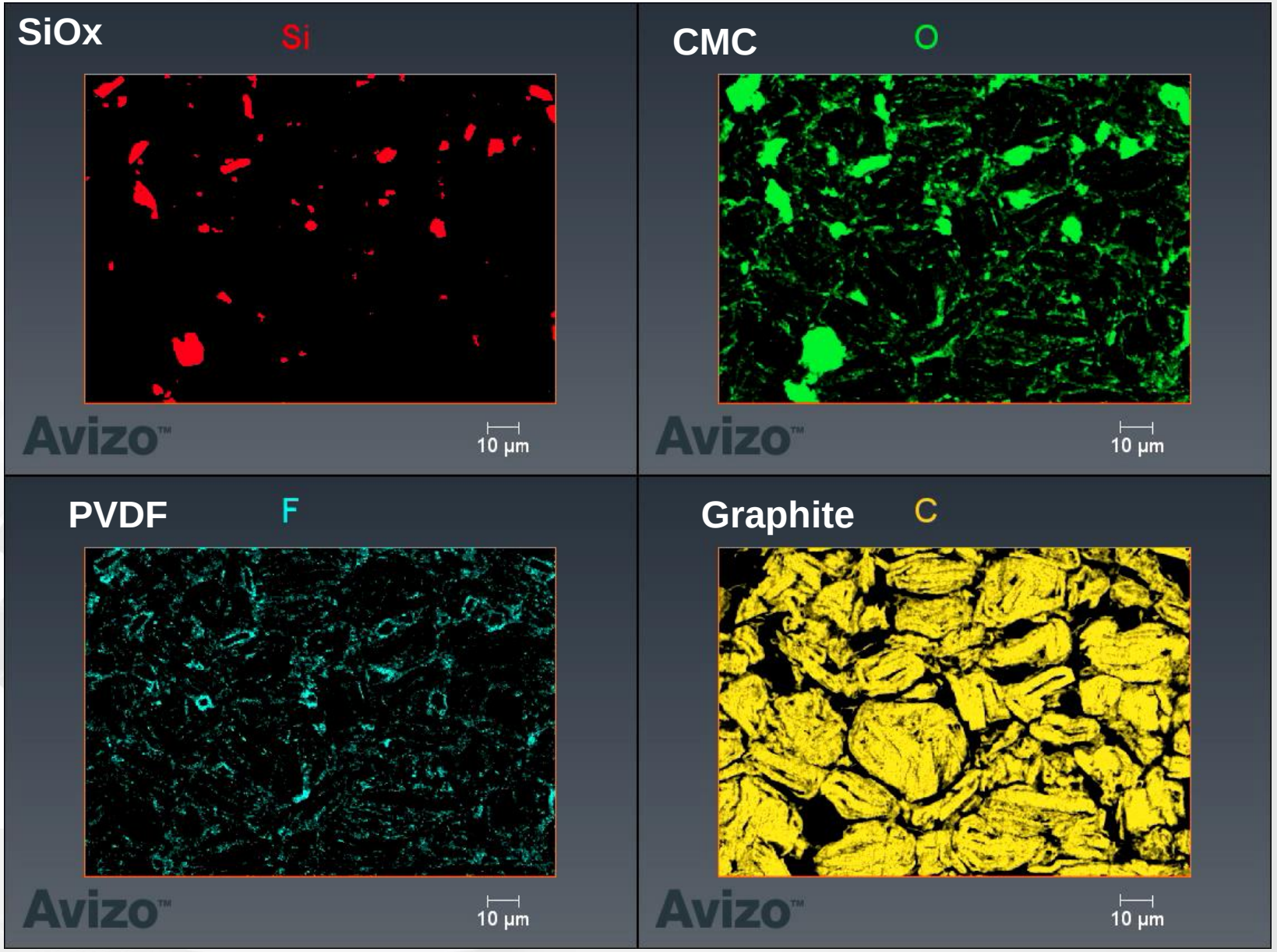
Composition analysis in 3D with EDS

Example: battery anode

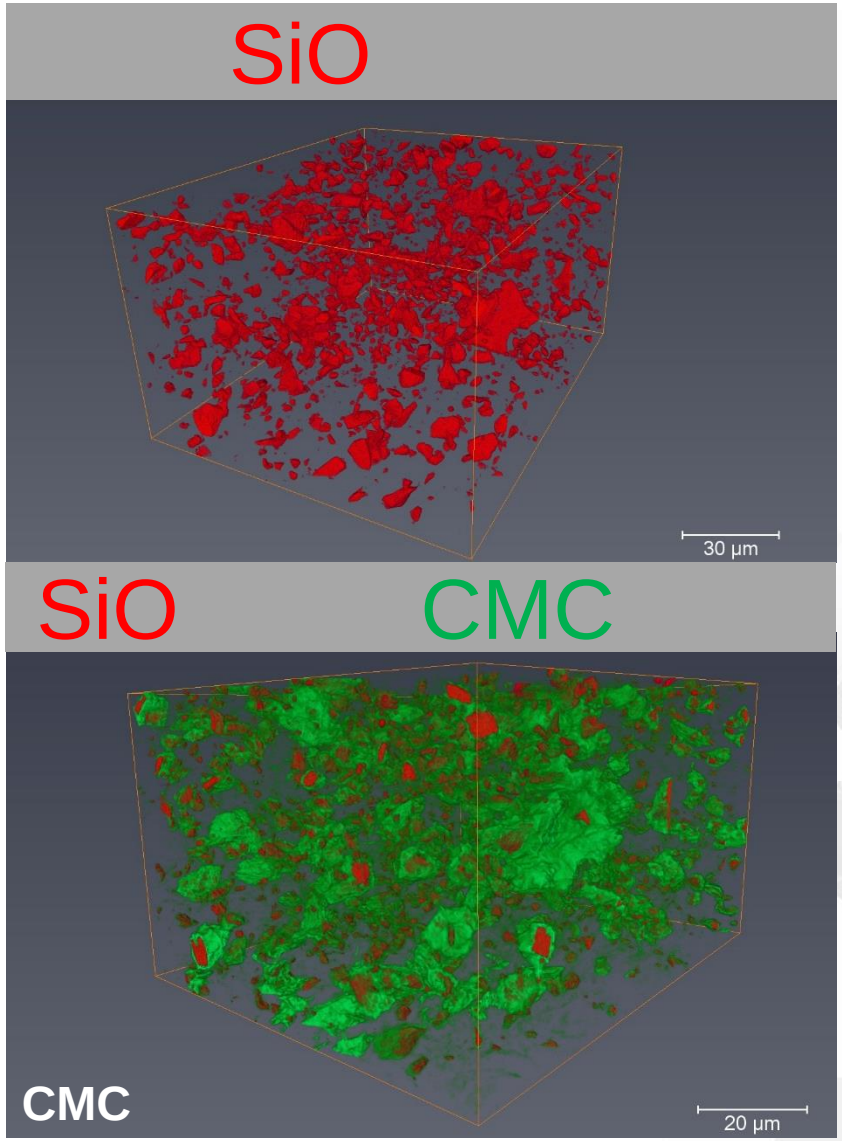
Adding Si to the graphite anode increases the electrochemical performance.

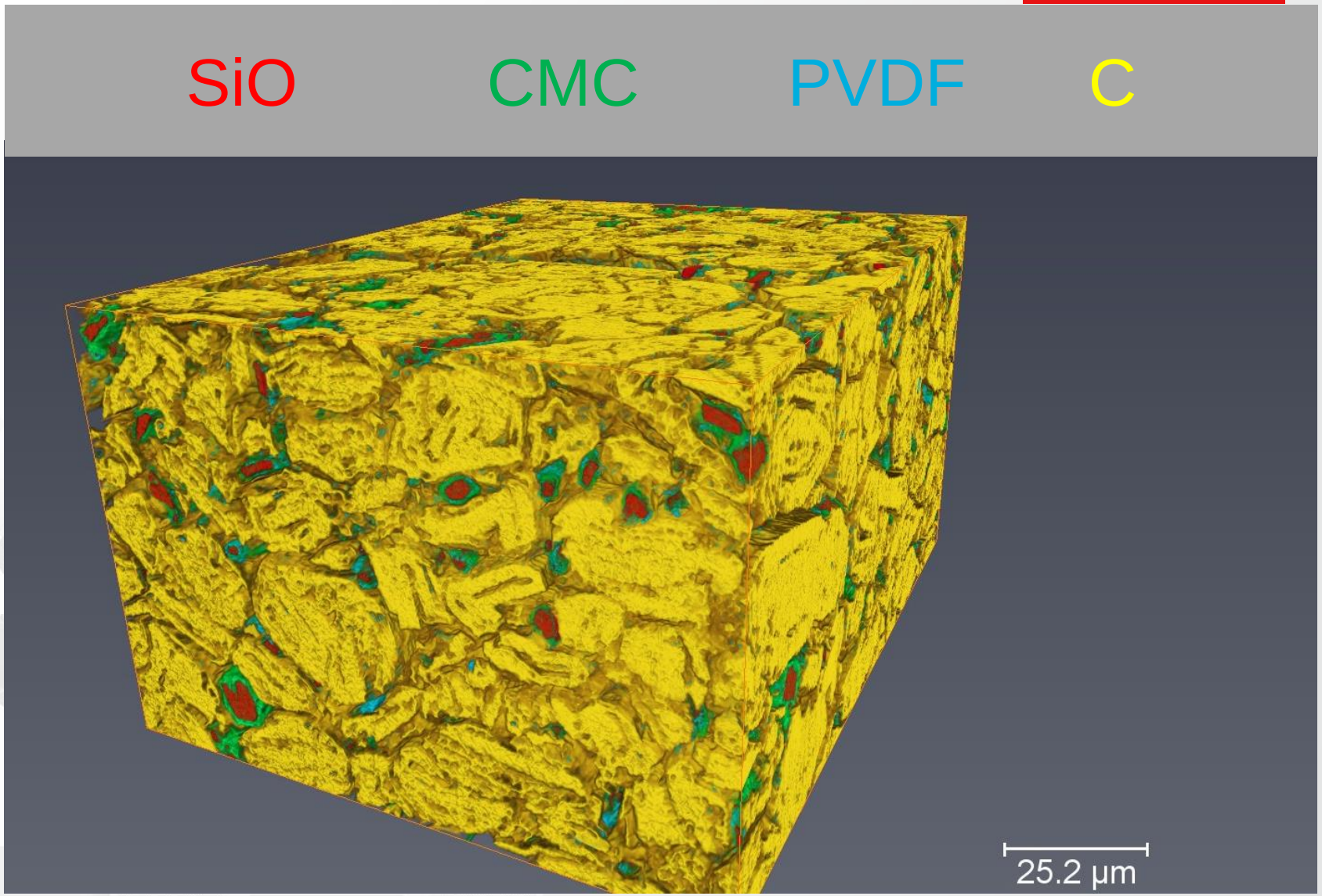
CMC (carboxymethylcellulose) is added as it has a higher binding strength to silicon and higher elastic moduli to withstand extremes volume changes than the traditional PVDF binder

EDS in 3D is used to see the distribution of Si and CMC



Anode composition in 3D with EDS





The CMC is seen to coat the Si particles in the graphite matrix

Failure analysis: impurity detection in pouch cell

Production FA: CT to EM for impurity analysis

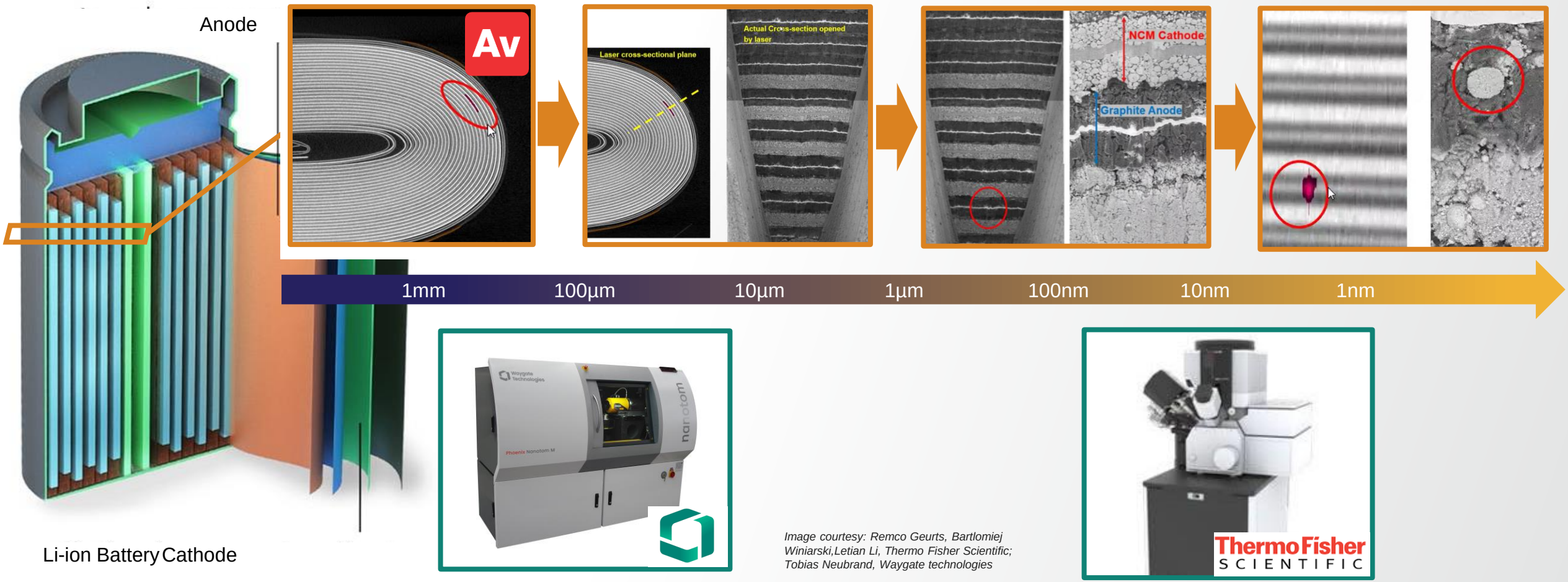


Image courtesy: Remco Geurts, Bartlomiej Winiarski,Letian Li, Thermo Fisher Scientific; Tobias Neubrand, Waygate technologies

Baker Hughes Confidential

Summary

- EM provides wealth of signals
- 3D FIB analysis correlates structure with property
- CT and EM are complementary techniques that WANT each other! ☺

Thank you