SOFC Imaging in 3D: Field of View or Resolution?

Introduction

3D imaging of Energy Materials such as batteries and fuel cells is commonly done with microCT or FIB-SEM technology. The microCT can typically image the entire structure of interest but lacks the resolution to see the smallest pores. The FIB-SEM will resolve these smallest features, but is typically limited to a Field of View of the order of 20 micrometer. A novel approach is presented where a FIB-SEM system with a PlasmaFIB instead of a Ga-based FIB column is used. This approach allows to get both good resolution and a Field of View that is representative for the transport properties of the sample

Experimental setup

All data is acquired on a Thermo Scientific Helios G4 PFIB DualBeam™; with high resolution SEM column and high current Plasma FIB column.
639 slices were imaged at following conditions:

- HFW 104 µm
- Slice thickness 40 nm
- SEM images at 5 kV, 0.2 nA, 5 µs dwell time
- 3072x2048 image size
- Concentric BackScatter Detector
- FIB milling at 180 nA

Figure 1. The area of interest between the two trenches.

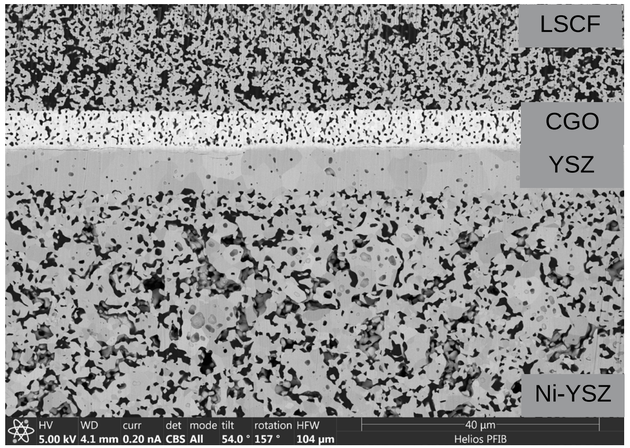

Figure 2. SEM image of the first slice (104 micrometer wide).

Results

A 3D volume is obtained that shows all layers in the fuel cell from the anode to the cathode. Thermo Scientific™ Avizo® software is used for artefact removal, filtering and segmentation of the images. A Pore Network Model is built from which tortuosity numbers are derived for the different layers in the fuel cell.
Segmentation is particularly difficult given the details that can be seen through the pores. This pore-back effect was filtered out by a combination of variance, threshold and 2D and 3D watershed algorithms.

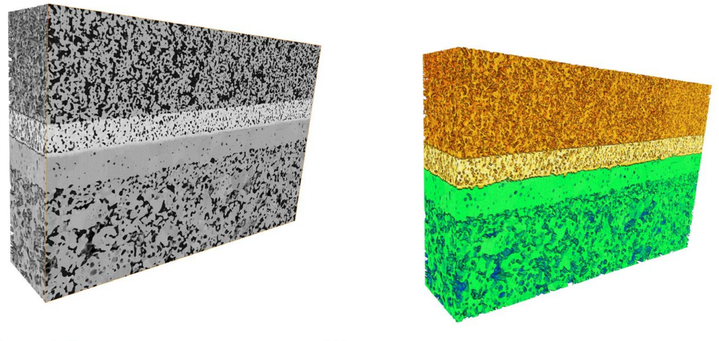

Figure 3. The reconstructed volume from 600+slices and the segmented pore space.

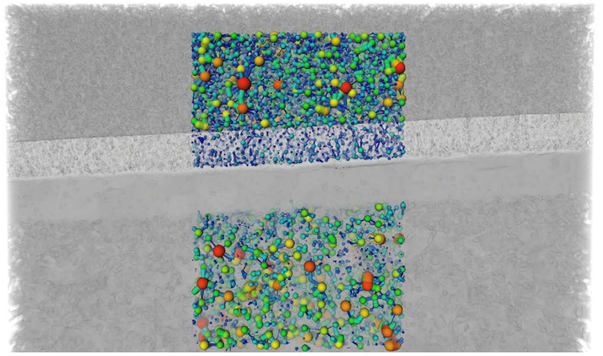

Figure 4. The ball-stick pore network model used for calculating tortuosity numbers.

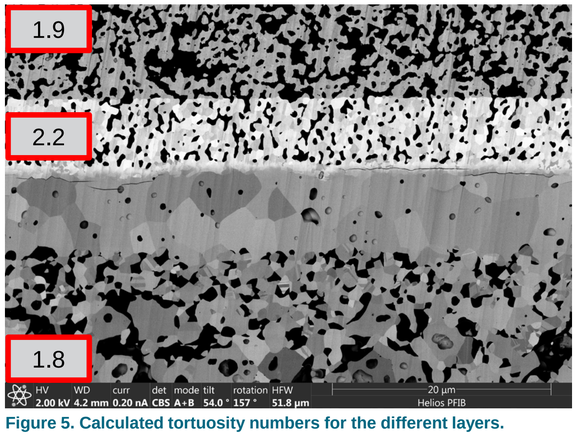

Figure 5. Calculated tortuosity numbers for the different layers.

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Conclusion

The Helios G4 PFIB DualBeam™ allows to visualize the entire structure of the SOFC at SEM resolution. No compromise was made between Field of View or Resolution.

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