Segmentation of 3-D images of solid oxide fuel/electrolyzer cell materials from electron microscopy.

Context
Solid oxide fuel cells (SOFC) are direct energy conversion devices that allow the production of electricity with high efficiency while maintaining pollutant emissions at a low level. In reverse mode (solid oxide electrolyzer cell, SOEC), hydrogen can be produced. Their lifetime is currently not yet sufficient in both modes for large-scale commercialization. Therefore, the degradation phenomena that affect their performance need to be understood in greater details. They are related to the aggressive high temperature environment and they range from local alterations of the microstructure to cracking of the brittle ceramic layers that form the cells. 3-D imaging methods, such as focused-ion beam -scanning electron microscopy (FIB-SEM) serial sectioning are now capable of imaging the complex heterogeneous materials used as electrodes with a resolution in the range of 10 nm. These methods are required to understand the relationships between the microstructure and the properties of the material. However, most analyzes (measurement of microstructural parameters, numerical modeling) require first the segmentation of the grayscale images produced by 3-D imaging methods, i.e., the identification of the different material phases. Accurate segmentation is therefore of crucial importance, but often proves difficult to achieve.

Objectives
This master project will aim first at improving standard segmentation procedures to process artifacts due to imperfect impregnation. In a second step, several geometrical concepts will be compared for the measurement of size distributions of composite SOFC/SOEC material.

Tasks
The project will start with a rapid literature survey of (i) segmentations methods and of (ii) metrics for assessing the quality of a segmentation and the errors in subsequent measurements of microstructural parameters, with an emphasis on the second. The workload for the implementation of methods for the processing of FIB-SEM serial sectioning data will be evaluated. The developed tools will be interfaced in the current semi-automatized 2-D and 3-D image processing workflow at GEM. The measurement of the size distribution of the different material phases in SOFC/SOEC materials is needed to quantify microstructural changes. The detection capabilities of methods based on different geometrical concepts, such as ray shooting or filling by overlapping spheres will be compared.