Comparison of the effective conductivity of solid oxide fuel/electrolyzer cell electrodes measured by 3-D imaging and conductivity measurements.

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. SOFC electrodes are heterogeneous materials comprising typically percolated voids, electron and ion-conducting phases. The electro-catalytic sites are located at the triple-phase boundaries, which are distributed within the material, to which electrons, ions and gas species must be transported. Therefore, the electrochemical performance of an electrode material depends upon the effective electronic and ionic conductivity of the reticulated phases. The performance of most solid oxide cell electrode materials is dominated by ion transport. Therefore, the precise measurement of the effective conductivity of the phases and the understanding of the relationship with the microstructure is key to improve the performance and durability of SOFC/SOEC electrodes.

Objectives
This objective of this master project is the comparison of the effective electronic and ionic conductivity measured by the van der Paw method and that computed by 3-D homogenization based on reconstruction from focused-ion beam -scanning electron microscopy (FIB-SEM) serial sectioning. The project will focus on the hydrogen electrode, which is a cermet made of yttria-doped zirconia (ceramic) and Ni (metal).

Tasks
The Ni-YSZ samples for this study are stripes (60×25×0.27 mm³) and are already available. The project will start with the preparation for conductivity measurements. An existing high-temperature setup will be prepared for the measurement of the electronic conductivity at 700-800°C in hydrogen during exposure for 1000 h. The ionic conductivity at 700-800°C in air will be measured on another sample, after dissolution of the Ni in acid. In a second part of the project, available 3-D reconstruction obtained by FIB-SEM serial sectioning will be segmented (identification of the material phases from their grayscale values), prepared for 3-D finite-element simulations, and the microstructure characterized using methods available at GEM. The time evolution and relationship between the microstructure and the effective transport properties measured by conductivity measurements and 3-D homogenization will be analyzed.