Molten Carbonate Fuel Cells (MCFCs) are an alternative type of power production devices where fuel (hydrogen or hydrocarbons) are transformed into electrical energy by electrochemical processes. There are several advantages placing MCFCs in a favorable position compared to conventional devices. In particular, zero or near zero net greenhouse gas emission, high energy conversion efficiency, quiet operation and heat production for distributed combined heat and power. This technology has been successfully commercialized in North America and Asia, where large (over 60 MW) power plants have already been launched.

The performance and durability of MCFC is mostly dependent on the materials used for the fabrication of the cell elements (anode, cathode and matrix). The anode and cathode layers (thickness 0.5-0.7 mm) are separated by an electricaly resitive matrix (0.8-1.0 mm) infiltrated with electrolyte, which at the operating temperature (over 600°C) is liquid and ion conductive. The materials used for electrodes, among many other properties, must allow fuel to be transported and catalytically decomposed at the surface. Thanks to the elevated temperature MCFC can be supplied with various fuels (not only hydrogen) and electrodes can be made of much cheaper catalytic materials (other than Noble metals). Thus, open-porosity materials (50-80%) based on nickel are typically used.

The development of MCFC within the last 20 years was based on intuitive approaches, where modifications of the microstructure and chemical composition were done with an insufficient understanding of the effect on the processes taking place during the operation of the fuel cell. This limited the progress that could be made and, in order to achieve further improvements, new (more systematic) methods are necessary.

The scientific goal of this project is to determine the influence of the microstructure and chemical composition on the catalytic properties of the molten carbonate fuel cells (MCFC) materials. This objective will be achieved by the synergic use of fabrication methods supported by multiscale modeling, and advanced characterization of the structure and properties of materials and processes taking place during the MCFC operation. Within the project novel materials (modified microstructure and chemical composition) will be manufactured by the tape casting method and characterized by using direct and indirect methods. 3D images, obtained by x-ray tomography and/or electron tomography, will serve as input data for representative models of the microstructure, which will be applied to modeling of the MCFC operation related processes (mass transport and capillary effects). Simultaneously, atomic-scale modeling will be applied to provide quantitative relationships between chemical composition and catalytic properties. The results of modeling and characterization will be continuously implemented and verified by testing of fuel cell components. A dedicated and unique test rig for the fuel cell assembly will be used to evaluate the MCFC under real working conditions and current/voltage characteristics will be registered for varying cell loads. The results will be used as feedback to adjust the models.

Using this framework will allow for providing quantitative relationships between the chemical composition, microstructure and properties of porous materials. The results obtained within the project will be published in high Impact Factor journals i.e. Journal of Power Sources, Materials&Design, International Journal of Hydrogen Energy and similar.