Description for the general public

Understanding and minimization of ohmic and polarization losses in solid oxide cells by nanocrystalline ceramic and cermet functional layers

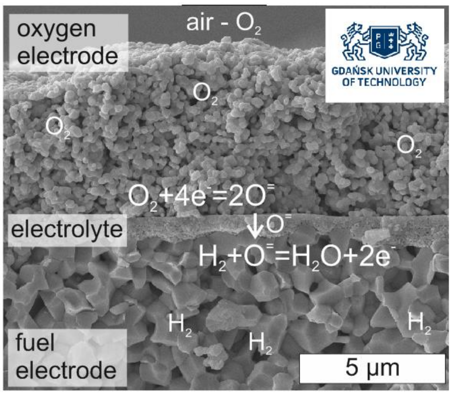
Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology,
ul. Narutowicza 11/12, 80-233 Gdansk, Poland.

Fuel cells are efficient energy conversion devices. They can transform chemical energy contained in the fuel directly into electricity (and heat). Conversion does not include any combustion steps like in traditional internal combustion engines, so the efficiency of energy generation can be very high. Typical conversion efficiency of high temperature fuel cells can reach 60% (if no heat is used) up to 85% (if heat is used). In addition, fuel cells can be ran in reverse as electrolysis cells. In this case, energy is delivered to the cell with reactant gases, like steam, that can be electrochemically converted into hydrogen and oxygen with high efficiency. Therefore, fuel cell technology is very versatile and gained attention of the research and the industrial community. Fuel cells are regarded as the enabling technology for the future renewable energy world.

The most important parameters of fuel cells are their power density (W cm^{-2}) and degradation rate (e.g. % per 1000 hours). Power density should be high, so that the size of the device can be small and the price/power ratio can be low. Degradation rate should be as small as possible, so that fuel cells will remain their power over long operation period. Unfortunately, often the devices with high power density also have high degradation rates. High chemical activity usually results in both high power and high degradation.

Figure shows a Solid Oxide Fuel Cell prepared at Gdansk University of Technology. Cell has a very thin electrolyte. Its thickness is below 2 µm, so much lower than the diameter of a human hair (~50 µm). Fuel cells fabricated at GUT have typically power densities of ~1 W cm^{-2}, with relatively high degradation rates (10-20 %/1000h).

Cross section of a Solid Oxide Fuel Cell



Proposed research project will work on improving the understanding and minimization of degradation processes occurring in fuel and electrolysis cells based on Solid Oxide Cells (SOCs). By tailoring the electrode microstructures (grain size, porosity), effects of the microstructure on electrode performance and stability will be described. Project work will focus on both the hydrogen and oxygen electrode and will thus offer a comprehensive understanding about electrode degradation process.

Research will be based on basic aspects of electrode degradation, e.g. agglomeration of nanomaterials (lowering of surface area) and will verify the possibilities to lower the degradation rate by chemical and structural modification of the electrode. After the initial characterization performed on the symmetrical electrodes, fuel cell tests will be carried out based on the fabrication methods available at GUT.

For the fabrication of the functional layers with tailored properties novel ceramic fabrication methods will be used (spray pyrolysis, infiltration etc.). These methods were developed in the laboratory in the last few years and have yielded interesting primary results that have been already published in international scientific journals.

The existing experience and laboratories offer obtaining original results with a large importance for the development of SOC technologies, including the high temperature fuel and electrolysis cells. Project results will be presented at national and international conferences and will be published in leading scientific journals.

The obtained knowledge about the degradation phenomena will have a chance to be used in the construction of the next generation SOFCs with improved parameters, leading to their faster deployment on a larger scale for clean energy generation for the benefit of the environment and the society.