Porous metal supported micro-scale solid oxide fuel cells: fundamentals, fabrication and testing

MSμSOFC

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The aim of the project is to *design, fabricate and characterize hydrogen fuelled micro Solid Oxide Fuel Cells* (μ-SOFCs) *with the support structure based on a porous steel substrate* (MS-μ-SOFCs). To achieve the goal, the project will develop tailored porous steel substrates, determine their corrosion properties. In parallel, work will progress on the fabrication of nanoporous ceramic and ceramic-metallic electrodes for efficient oxygen reduction and hydrogen oxidation at low temperatures (<500 °C). For obtaining highly performing materials and layers, use of microelectronic (MEMS) fabrication techniques (laser/magnetron deposition, laser microdrilling etc.) for electrolyte deposition and structuring of the cells will be pursued.

The project plans combining extensive research experience of three groups:

- **Gdańsk University of Technology** (PG, Poland) – specialized in porous metal substrates fabrication and corrosion characterization, high temperature fuel/electrolysis cell testing and nanocrystalline oxygen electrode development;
- **Warsaw University of Technology** (PW, Poland) – with great experience in detailed materials characterization, including especially transport phenomena in mixed ionic-electronic conductors;
- **Kaunas University of Technology** (KTU, Lithuania) – experienced in cleanroom based and ultra-short pulsed laser based lithography processes for advanced microelectromechanical system (MEMS) including thin film preparation by physical vapour deposition techniques and thin layers structural and elemental characterization methods;

Research hypothesis is that robust μ-SOFCs can be built on porous stainless steel supports. In contrast to other μ-SOFC cells, porous metal supported cells will allow rapid thermal cycling (start-up, cool-down) and, due to ceramic based electrodes will survive reduction-oxidation cycles. These cells, with active area of at least 1 cm^2 will operate at temperatures < 400°C with power density exceeding 100 mW cm^{-2}.

To develop superior low-temperature electrodes for MS-μ-SOFC, nano- and microstructure of the materials will be optimized (thickness, porosity, particle size) and the reaction mechanisms will be studied in details on symmetrical electrodes to determine the rate limiting processes, which will be subsequently improved by introducing appropriate electrode modifications.

Electrolyte materials based on ceria oxides (potentially with electron blocking layers) will be tested and optimized for high ionic conductivity by proper sintering and/or doping strategies (grain and grain boundary engineering).

Specially tailored porous metal supports will be fabricated and their corrosion resistance in relevant conditions will be studied (atmosphere – air, humid H_2 and temperature – 200 - 500 °C), including the mechanical properties.

Realization of the project idea will contribute to the fundamental understanding of μ-SOFC performance and durability limitations and will lead to a novel μ-SOFC structure based on a porous steel (Metal Supported μ-SOFC). Electrodes with good electrocatalytic properties at temperatures <500°C will be developed and studied for their stability. Proposed construction will allow improved electrical and thermal conductivity in comparison to other μ-SOFC/SOFC configurations and will be inexpensive due to use of cheaper and efficient processing methods. Also, mechanical durability of the cells should be greatly improved.