Construction and Testing of a Test-Rig for Micro-Solid Oxide Fuel Cell Arrays with Integrated Reformer

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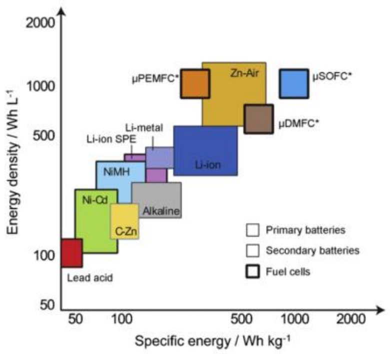
Collaborative project between “Electrochemical Materials” (D-MATL) (http://www.electrochem.mat.ethz.ch) and “Laboratory of Thermodynamics in Emerging Technologies” (D-MAVT) (http://www.ltnt.ethz.ch).

Micro-solid oxide fuel cells (micro-SOFCs) are potentially an alternative power supply to Li-ion batteries for portable electronics operating on fuel and air, independent from the electric grid. The first proof-of-concept for power delivery of such single membranes was illustrated recently for low operating temperatures between 100 and 600 °C on a laboratory scale. This new type of solid oxide fuel cell requires the active cell components as tri-layers of cathode electrolyte and anode thin films forming a mechanically free-standing fuel cell membrane integrated on a Si-wafer substrate. Major advantage towards Li-ion battery technologies are the 2-3 times increased energy densities; compared to other micro-fuel cell systems such as polymer or direct methanol fuel cells the 2-5 times increased specific energies and opportunity to operate on hydrocarbons. Review on the field is given in Ref. 1.



Till date *single* laboratory cells have been processed, contacted and tested delivering power of several hundreds of mW/cm^2 for 300-500°C. Here, state-of-the-art is the testing with *hydrogen* as a fuel.

Two aspects are to be developed to improve efficiencies at high energy density for micro-SOFCs on a Si-chip:

i. <u>Alternative testing routes to measure micro-Solid Oxide Fuel Cell *arrays* in various interconnections.</u> This requires a new test-rig design whereby more than a single membrane can be tested through automatic controllable micro-contactors with the help of a stereomicroscope. Challenge is here to assure a controlled gas access from both sides of membranes (fuel at anode and air at cathode), manage microfluidics of array, operate cells at high temperatures (300-500°C) and measure current-voltage profiles and impedances of more than one membrane.

ii. <u>Integrate a *micro-reformer which converts a hydrocarbon fuel* into a hydrogen-rich gas into the micro-SOFC array test rig.</u> Come up with suitable design suggestions for test-rig construction. LTNT has successfully shown that model large-scale SOFCs (several mm in thickness for membranes) reveal efficient operation with an own processed micro-reformer. Through this work the micro-reformer is to-be-integrated in the new design for the fuel cell array test rig. Microfluidics and impact on cell performances of arrays are to be investigated.

Overall, the present master thesis project is a challenging but feasible goal which connects different fields such as mechanical and chemical engineering, micro-electronics, and material engineering. Special emphasis is given on the design and construction of the test rig and on the characterization of the cells.

A proof-of-concept of the constructed test rig is to be demonstrated on power output and characteristics of SOFC array dummy structures (D-MATL) with an integrated micro-reformer (D-MAVT) for various hydrocarbons. Selected micro-SOFC array structures for testing in new constructed rigs will as well be provided by D-MATL.

References:

[1] A. Evans, A. Bieberle-Hütter, J. L. M. Rupp and L. J. Gauckler, J Power Sources 194 (1), 119 (2009)