The Fourth International Workshop on
Micro and Nanotechnology for Power Generation
and Energy Conversion Applications
PowerMEMS 2004
November 28 - 30, 2004
Kyoto, Japan

Micro Fuel Cell Systems – from Simulations to System Technology

Christopher Hebling
Fraunhofer-Institut für Solare Energiesysteme ISE
Heidenhofstraße 2, 79110 Freiburg
Christopher.Hebling@ise.fraunhofer.de, Tel.: +49-761/4588-5195, Fax +49-761/4588-9320

Small fuel cells can play an important role in the power supply of portable and remotely located off-grid electronic appliances such as medical appliances, sensors, global area network components or consumer electronics like the various classes of mobile computing devices, usually categorized as 4C-products (camcorders, cell phones, computers, cordless tools). The major driver for fuel cell systems is the fact that the improvements in the energy density of batteries have not kept pace with the growing power demand of such units which again is a result of an increase in intelligence (computation), connectivity (band width) and the promotion of 'always on'. This development can be slowed down a little bit by low power micro controller or new kinds of low power displays (e.g. OLEDs) but the general trend will remain like this.
There are plenty of intrinsic properties of fuel cell systems which make them attractive candidates as a new generation of power sources for mass market products next to batteries. Fuel cells can be laid out exactly according to the power demand of the device and the fuel storage can be dimensioned due to the service time which should be achieved. This is different with batteries where the capacity is an integral part of the power source. Compared to batteries, fuel cells do show their greatest benefits whenever small power requirements are combined with a long operation time. Depending on the application and the boundary conditions, small fuel cells can be used both as a supplement or as a substitute to batteries. However, many aspects such as cost issues, technical challenges, fuel infrastructure, safety issues as well as the need for a different usage and maintenance by the customer as compared to batteries need to be considered as well.
The major research issues to be adressed in terms of micro fuel cells are within the field of materials improvements. One of the key components, the membrane electrode assembly (MEA) for example is a highly complex unit consisting of an ion-conducting membrane covered with a three-dimensional electrode containing the catalyst. Additionally, for a reliable operation of micro fuel cells, hydrophilic and hydrophobic properties of the electrode and the adjacent gas diffusion carbon cloth have to be designed and used appropriately in order to remove the emerging water of the overall chemical reaction.

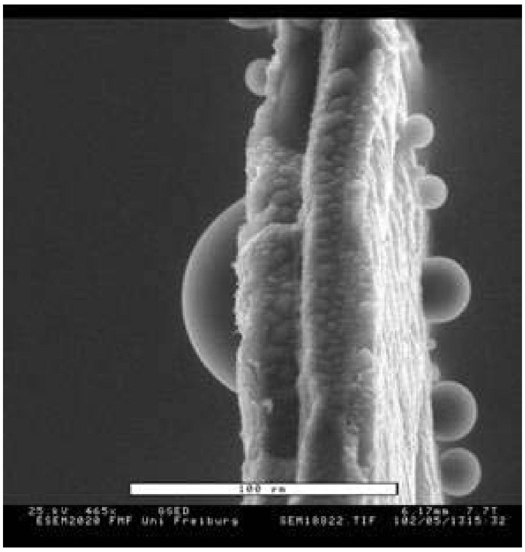

Fig. 1: ESEM picture of a degraded membrane elcectrode assemby in order to study the hydrophobicity change of the two catalyst layers.

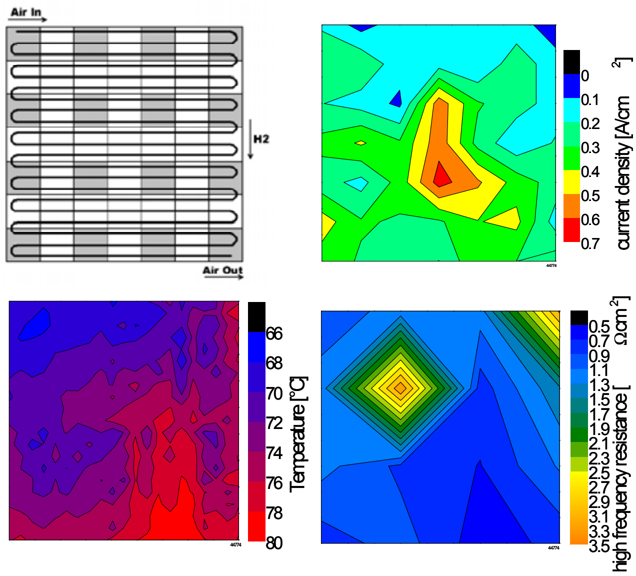

Fig. 2: Spacially resolved in-situ measurements of a single fuel cell under operation. The comparison of the extracted data allows for a profound understanding of the electrochemical, thermodynamical and mass transport procedures under given boundary conditions.