Institute of
Technical Thermodynamics

A Novel Concept for In-Situ Gas-Phase Laser Raman Spectroscopy for Solid Oxide Fuel Cells

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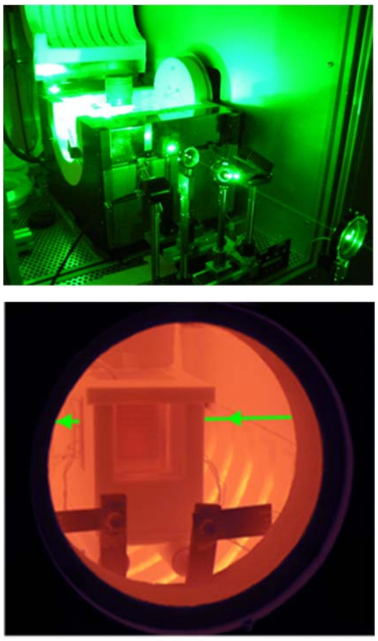
Introduction

The application of in-situ diagnostic methods by monitoring cell characteristics under real operating conditions can provide detailed information about the spatial distribution of the electrochemical, chemical and thermal properties in order to increase the fundamental understanding and to optimize the operational behavior. DLR has developed and applies different analytical techniques for in-situ characterization of SOFCs:

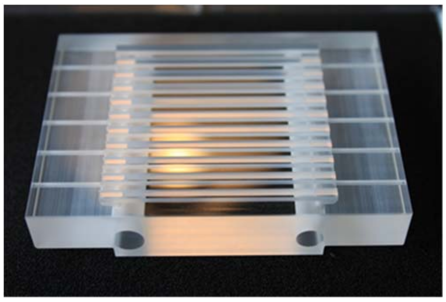
- Electrochemical impedance spectroscopy (EIS) for cells and stacks
- Spatially resolved diagnostics with segmented cell technology (i,V,T,c)
- Imaging techniques, such as optical microscopy and 1-dimensional laser Raman spectroscopy

Experimental setup

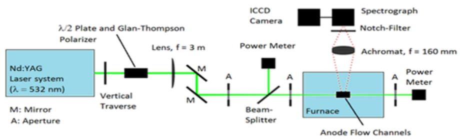
Gas-phase laser Raman spectroscopy has been adopted to determine the concentrations of relevant gaseous species within the anode flow channel with high spatial and temporal resolution during SOFC operation. A test rig has been built up which gives optical access to the flow field of an electrolyte supported SOFC cell (50x50 mm²) through transparent windows in the furnace and using a transparent anode flow field entirely consisting of quartz glass. The Raman experiments were performed by means of a laser system using three double pulse Nd:YAG lasers. Details of the experimental setup are shown in the following pictures.



Photos of furnace and cell compartment



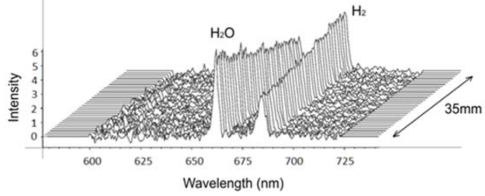
Transparent anode flow field consisting of quartz glass with 9 channels (3x4 mm²)



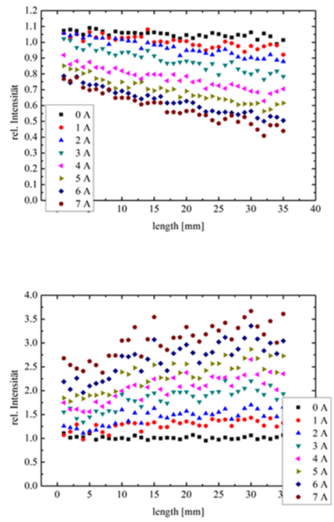
Schematic of the experimental setup

Results and discussion

Here we present some exemplary results for 1123 K, dry H_2 as anode gas (1.25 slpm) and air (1.25 slpm) for different currents between 0 and 7 A (0-437 mA/cm²). The 35 spectra cover a length of 35 mm along the channel.



Raman spectra recorded during operation at 1123 K with H_2 (λ=683 nm for H_2, λ=660 nm for H_2O)



H_2 (top) and H_2O concentrations (bottom) along the flow channel

Conclusion

A number of initial experiments to analyze chemical species conversion within a SOFC flow channel was performed by means of in-situ gas-phase laser diagnostics. The results demonstrate the feasibility of measuring species concentration profiles in this arrangement. In the next step, quantitative species concentrations (CH_4,H_2,H_2O,CO,CO_2,N_2) will be determined to investigate internal reforming processes.

Literature

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G. Schiller, C. Auer, W. Bessler, C. Christenn, Z. Ilhan, P. Szabo, H. Ax, B. Kapadia, W. Meier, Appl. Physics B, Vol. 111 (1), 29-38 (2013)

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