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DEVELOPMENT OF REDOX STABLE, MULTIFUNCTIONAL SUBSTRATES FOR ANODE SUPPORTED SOFCS

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Abstract **- Redox stable solid oxide fuel cells are beneficial in many aspects such as tolerance against system failures e.g fuel cut off and emergency shut down, but also allow for higher fuel utilization, which increases efficiency. State-of-the-art Ni-cermet based anodes suffer from microstructural changes upon redox cycling, while other properties such as catalytic activity for methane reforming and/or water gas shift, thermal conductivity in addition to electronic conductivity for current pickup are highly wanted for SOFC applications.**

In order to combine the advantages of a redox stable anode with a multifunctional anode support, the development of a two layer fuel electrode based on a redox stable strontium titanate layer for the electrochemically active layer and a redox stable Ni-YSZ support was pursued. Half-cells with well adhearing strontium titante anode layers on state-of-the-art Ni-YSZ cermet supports have been achieved. Redox tolerance of the half-cell depends could be increased by optimizing the redox stability of the cermet support.

Index Terms **– SOFC, anode supports, redox stability, ceramic anode.**

I. Introduction

Redox stable solid oxide fuel cells are beneficial in many aspects such as tolerance against system failures e.g fuel cut off and emergency shut down, but also allow for higher fuel utilization increasing efficiency. Related to redox tolerance, is also overload tolerance.

State-of-the-art Ni-YSZ cermet electrodes can be tailored in microstructure so they possess a certain redox stability, however, usually through a coarse grained microstructure on the expense of electrochemical activity.

A redox stable anode can be prepared by mixed or electronically conducting ceramics, and promising results have been published for strontium titanate based electrodes infiltrated with electrocatalytically active metal particles [1,2]. However, these ceramic materials suffer from low mechanical strength, low electrical and thermal conductivity and insufficient catalytic activity for internal reforming or water-gas shift reaction. All these properties are known to be important for efficient operation of SOFC cells, and are usually provided by a Ni-cermet based anode support (see Fig. 1).

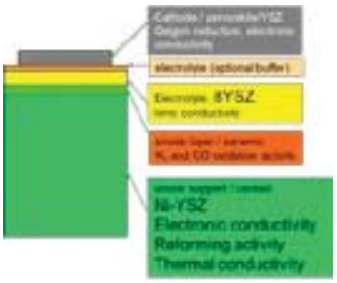

Fig. 1. Concept of a redox stable anode supported SOFC

In order to combine the advantages of a redox stable anode with a multifunctional anode support, the development of a two layer fuel electrode based on a redox stable ceramic anode layer for the electrochemically active layer and a redox stable Ni-YSZ support was pursued.

II. Results

The concept of the redox stable, multifunctional anode anode support is shown in Fig. 1, indicating the different layers and functionalities. Cells with strontium titanate based anode layers ($Sr_{0.94}Ti_{0.9}Nb0.1O_{3-\delta}$) (STN) and Ni-

YSZ ($Zr_{0.84}Y_{0.16}O_{1.92}$ (8YSZ)) anode supports have been prepared by tape casting the individual layers and subsequent lamination and sintering

Fig. 2 shows an STN anode (middle layer) integrated onto a NiO-8YSZ support (bottom) with a Sc-modified zirconia electrolyte layer (top layer). Well adhearing layers can be achieved for various types of Ni-YSZ supports and both yttria and scandia modified zirconia as electrolyte layer. The cells could be successfully reduced in 9% H_2 at 850 C without any visible damage to the microstructure.

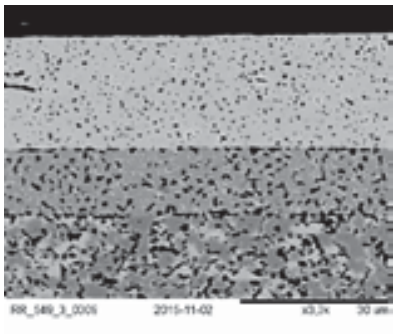

Fig. 2. Microstructure of a STN anode layer integrated between a Sc-stabilized zirconia electrolyte (top) and a NiO-YSZ cermet (bottom) layer

The cells were further tested as regards their redox tolerance by two redox cycles between 9% H_2 in Ar humidified with 3% water and air at 850C. Fig 3 shows the microstructure of cells with a "standard" Ni-YSZ anode support with an STN anode and 8YSZ electrolyte layer. While the anode support has survived the redoc cycles, cracks have been developed through the electrolyte and anode layer, most probably resulting from dimensional changes in the anode support during re-oxidation.

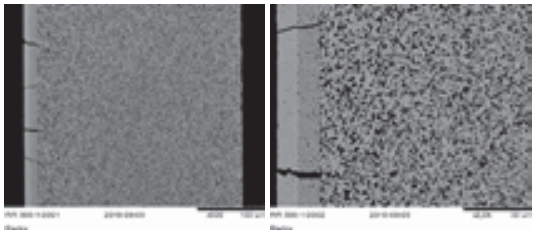

Fig. 3. Microstructure of a "standard" Ni-YSZ anode supported cell with STN anode after redox cycling

The redox tolerance of anode supports can to a large extend be tailored by the Ni/YSZparticle size distribution and the Ni-volume fraction in the Ni-cermet [3,4].

Fig 4 shows the microstructure of an STN layer integrated onto a redox optimized Ni-YSZ support after redox cycling. Significantly reduced number cracks through the anode and electrolyte layer are observed, indicating an increased redox stability of the anode supported half-cell.

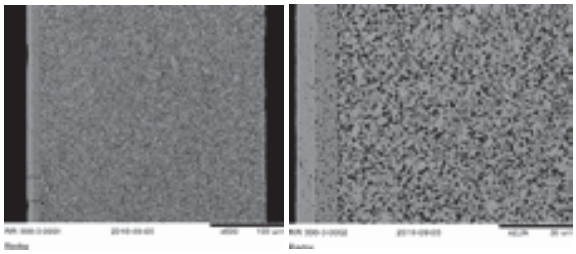

Fig. 4. Microstructure of a redox optimized Ni-YSZ anode supported cell with STN anode after redox cycling

III. Conclusion

Ni-YSZ cermet based anodes and supports are state-of-the-art and have been developed up to industrial fabrication. Redox stable ceramic anode layers can be integrated into standard Ni-cermet anode supports, which allows for the development of a full redox stable anode supported cell, without the need for completely new substrate developments. This has been proven on a rather fine-grained Ni-YSZ support, and even better redox stability is expected by using more coarse, low Ni-containing anode supports.

Acknowledgment

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