DENSIFICATION OF SOFC YTTRIA-STABILIZED ZIRCONIA ELECTROLYTES THROUGH ADDITION OF SINTERING ADDITIVES

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ABSTRACT

The use of sintering additives for fully yttria-stabilized zirconia (8YSZ) was investigated in order to reduce the sintering temperature. Both state-of-the-art SOFC systems, i.e. the tubular Siemens-Westinghouse design and the planar anode-supported system, were electrolyte-coated by wet chemical methods (e.g. vacuum slip casting and wet powder spraying) with different sintering aids. For the planar system alumina was used while in the tubular system boron nitride was investigated. The addition of low amounts of alumina (< 2%) resulted in either better gastightness of the electrolyte sintered at 1400°C or in comparable gastightness (in comparison to the normally used 8YSZ without additions) at lower sintering temperatures. The performance of single cells is enhanced by additions of alumina for all temperatures measured (750-900°C). For the tubular system low amounts of boron nitride (< 2.5%) led to a strong decrease in the sintering temperature necessary to reach gastightness (< 1300°C). The reaction mechanism for enhanced densification of both sintering experiments was examined.

Planar Anode-supported system

The effect of the addition of small amounts of alumina (0.77 to 4 wt%) on the helium leak rate of the electrolyte sintered at 1400°C for 2 or 5 hrs can be seen in figure 1. The best results were yielded by samples with small additions (0.77 wt%) and a dwelling time of 5 hrs (~ 1 x 10^{-7} mbar l / s cm²). But even additions of 0.77 and 2 wt% and a reduced dwelling time of 2 hrs result in dense electrolyte layers (< 2 x 10^{-5} mbar l / s cm²). This leak rate is the internal threshold value for electrolyte layers manufactured by Research Center Jülich.

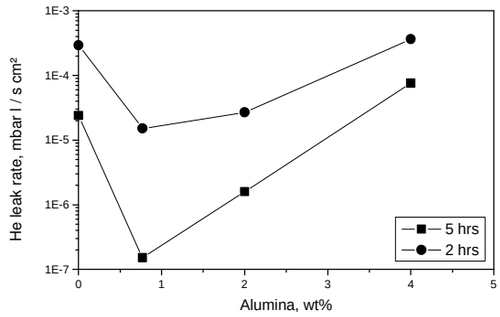

Fig. 1: He leak rate of samples sintered at 1400°C for different dwelling times (2 and 5 hrs) and with various alumina additions

Tubular SOFC system

A characteristic cross section of a sample with a gastight electrolyte layer is shown in figure 2. The figure shows a 30-µm-thick electrolyte layer on a tubular SOFC without an intermediate interlayer. The grain sizes are in the range of 8-15 µm. The resulting porosity is closed and thus the layer is gastight. It was found that at the grain boundary zirconia is depleted while an enrichment of calcium, manganese and lanthanum can be detected. This is a first indication that the densification of the electrolyte layer is supported by a liquid phase. This liquid phase consists mostly of components present in the cathode material.

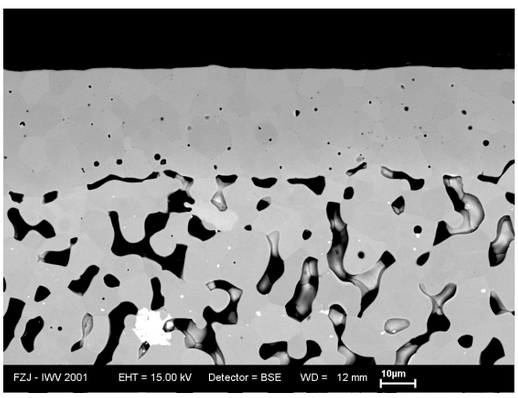

Fig. 2: SEM cross section of densified electrolyte layer on tubular SOFC (without interlayer)