High performing SOFC via multilayer tape casting?

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Publication date: 2015

Document Version
Peer reviewed version

Citation (APA):
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Aim – Decreased SOFC manufacturing cost while keeping high fuel cell performance:
Substitute processing steps that have low material yield (e.g. spraying) and those not suitable for industrial scale production. Decrease number of sintering steps and handling efforts.

- Multilayer tape casting (MTC) and co-sintering of support layer, anode and electrolyte could be a solution!

Questions:
1. Can the entire anode half cell be produced via multilayer tape casting?
2. Can we co-cast anode and electrolyte layers at thicknesses of just 10-15µm?
3. Can we obtain optimal microstructures for all half cell components in one single sintering step providing high performing anodes?

Microstructure

The MTC anode half-cell

Microstructural analysis:
Phase fractions and mean intercept lengths

Low voltage SEM: The percolating Ni network

High voltage SEM: Impact of sint. temperature

Electrochemical performance

Findings

DTU Energy Conversion produce SOC anode half-cells by MTC and co-sintering in a pre-plant pilot. Investigations of microstructure and performance of cells (Ni/YSZ-Ni/8YSZ-8YSZ/LSM/YSZ) with MTC anodes reveal:
1) A “window” for the co-sintering from 1255°C to 1335°C
2) Uniform microstructures of desired thicknesses, porosities, particle sizes and percolation
3) High initial performance
4) Correlations of microstructure and performance with sintering temperature – increased porosity and decreased Ni particle size with lower sintering temperature → decreased gas diffusion and charge transfer reaction resistance in the Ni/YSZ anode half cell.

Figure 5: Nyquist (left) and DRT plot (right) of impedance spectra (IS) at 850°C, OCV, air to the cathode, 21-23% H2O in H2 to the anode. The Nyquist plot is corrected for inductance.

Figure 6: IV curves at 850°C, air to the cathode, 4% H2O in H2 to the anode.

Figure 7: Equivalent circuit model applied in CNLS fitting of IS shown in Figure 5. Inductance L and series resistance Rs are connected in series with 5 EQ elements, representative of the polarisation resistance. Corresponding results are given in Table 1.

Table 1: ASRth at 700 mV from IV-curves in Figure 6 and resistances and summit frequencies from CNLS-fit of the IS shown in Figure 5. Estimated error for the resistances ±3 mΩ/cm².

Sintering temperature: 1255°C → 1335°C

Microstructure

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<td>1)</td>
<td>2-fold increase in gas diffusion resistance</td>
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<td>2)</td>
<td>Increase in charge transfer reaction resistance from 52 mΩ/cm² to 85 mΩ/cm² (850°C)</td>
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