Development and Characterisation of Solid Oxide Electrolyser Cells (SOEC)

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Outline

• Introduction

• Cell Manufacturing

• Electrochemical Characterisation

• Experimental Results

• Conclusion and Outlook
Fluctuating Regenerative Current Production

Vertikale Netzlast und Windenergie-Einspeisung in das E.ON Übertragungsnetz

Datum

Angabe übersteigt Nachfrage bei Weitem

Angabe kann Nachfrage nicht decken

Vertikale Netzlast

Geschätzte Windleistung 2020

Tatsächliche Windleistung 2007

Ludwig-Bölkow-Systemtechnik GmbH, 2008
Hydrogen as Storage Option

Source: LBST
Manufacturing Steps of SOFC Anode-Supported Cells

1. Substrate: Warm pressing with Coat Mix® powder or tape casting at 1200°C.
2. Anode: Screen printing at 1200°C.
3. Electrolyte: Cofiring of anode and electrolyte at 1400°C.
4. Cathode: Screen printing at 1100°C.
5. Current collector: PVD-CGO.
6. Solid oxide fuel cell: Laser-cutting to dimensions up to 200 x 200 mm².
Manufacturing Scheme of SOFC Anode-Supported Cells

- **Substrate manufacturing**
  - Coat-Mix + warm pressing / Tape casting

- **Debinder + Pre-sinterung**

- **Anode + electrolyte**
  - vacuum slip casting / screen printing

- **Co-firing**
  - 1400°C

- **Firing**
  - 1000-1200°C

- **Cathode**
  - screen printing / wet powder spraying

- Pressed size: 33 x 33 cm²
- Cast width: 50 cm²
Solid Oxide Electrolyser Cells: Planar Design

Materials
Anode: (La, Sr)(Fe, Co)O$_3$
Diffusion barrier: CGO – 1-5 µm
Electrolyte: 8YSZ – 5-10 µm
Cathode: Ni/YSZ
Cathode Substrate: Ni/YSZ
Evaporator for Steam Generation

Challenge:
Pulse-free steam generation
I-V Curves at 750 °C as a Function of Steam Content
(Flow rates: 2 l/min H₂/H₂O, 3 l/min air)
I-V Curves at 800 °C as a Function of Steam Content
(Flow rates: 2 l/min H₂/H₂O, 3 l/min air)
Impedance Spectra at 800 °C and 40% Steam Content as a Function of Current Density
Impedance Data at 40% Steam Content in Dependence of Current Density

Area Specific Resistance / mOhm*cm²

Current density / A*cm⁻²
Impedance Data at 60% Steam Content in Dependence of Current Density
Impedance Data at 80% Steam Content in Dependence of Current Density

Area Specific Resistance / mOhm*cm² vs. Current density / A*cm²²
Conclusion and Outlook

- SOFC standard cells from Forschungszentrum Jülich have been characterised in electrolysis mode at 750 and 800 °C in dependence of different steam contents.

- The cells show good performance; long-term tests and degradation studies have not yet been performed.

- Future activities will focus on improvement of performance by variation of stoichiometry of air electrode and on material variation of fuel electrode.

- Long-term measurements of > 1000 h at high current density (> 1 A/cm²) and high humidification (> 60% AH) will be performed to identify degradation mechanisms and to develop mitigation strategies in order to obtain highly efficient and durable SOEC cells.
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