Electrochemical Impedance Spectroscopy on Industrially-Relevant Solid Oxide Electrolyzer Cell Stacks: A Powerful Tool for in-Situ Investigations of Degradation Mechanisms

In the current efforts of moving energy production to renewable sources, wind and solar energy are widely considered as the key technologies to cover our growing demands. However, the fluctuating nature of these sources requires a flexible energy system and storage technologies to ensure that energy services can be covered in a stable and affordable manner. One promising solution is the synthetic fuel production by solid oxide electrolyzers. Electricity can be stored in a power-to-gas process during times of excess electricity production and then further converted to liquid fuels for e.g. transportation, or at high demands converted back to electricity by either conventional power plants or fuel cells.

One of today’s biggest hurdles for a successful commercialization of solid oxide electrolyzers is the stack’s lifetime with current industry targets in the order of five to ten years. To identify and quantify the different degradation mechanisms sensitive in-situ analysis tools are needed. On single cell level, electrochemical impedance spectroscopy (EIS) is a well-established diagnostics tool. On stack level EIS has been shown to be more difficult because of geometrical restrictions of the stack design and significantly lower resistances due to the larger active cell area. Nevertheless, it is becoming a more and more important technique for stack diagnostics.

Here we present impedance spectroscopy results of two solid oxide stacks provided by Haldor Topsoe A/S. The first stack was a 14-cell stack (Delta design) specifically optimized for EIS measurements, while the other stack was an 8-cell stack (TSP-1 design), where impedance measurements were carried out without major modifications to the stack. The individual cell voltages were monitored simultaneously by EIS during up to 2000 hours in electrolysis within the ForsKEL project 2015-1-12276 “Towards Solid Oxide Electrolysis Plants in 2020”, funded by Danish Energet.dk. The analysis provides valuable insight into the degradation processes which could not have been obtained by current-voltage-data alone.

General information
Publication status: Published
Organisations: Department of Energy Conversion and Storage, Mixed Conductors, Applied Electrochemistry, Haldor Topsoe AS
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Publication date: 2016
Peer-reviewed: Yes

Publication information
Journal: Electrochemical Society. Meeting Abstracts (Online)
Volume: MA2016-02
Article number: 3068
ISSN (Print): 2151-2043
Original language: English
URLs: http://ma.ecscdl.org.proxy.findit.dtu.dk/content/MA2016-02/40/3068.abstract?sid=70825e1c-811f-45d9-8161-3689170919a2
Research output: Contribution to journal › Conference abstract in journal – Annual report year: 2016 › Research › peer-review