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Electrochemical Characterization of a 10 layer Solid Oxide Electrolysis Stack operated under pressurized conditions

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Summary.

A commercially available planar 10 layer solid oxide electrolysis stack with electrolyte supported cells was characterized in an operating pressure range between 1.4 and 8 bar. Current-voltage characteristics and impedance spectroscopy were carried out by varying reactant gas composition, steam utilization and operating temperature.

Abstract.

The major part of the prospective power supply system will be based on solar and wind energy. The associated intermittency of energy supply due to varying weather conditions requires flexible storage and usage options. Converting electrical into chemical energy could be an essential constituent in this challenge. One promising path is the solid oxide electrolysis cell (SOEC) technology which can highly efficiently provide chemicals like hydrogen or derived hydrocarbons from electricity. These products can be used as fuels in mobility, for the chemical process industry, for conversion back to electricity or heating.

SOECs offer a great potential for a highly efficient energy conversion due to their high operating temperature. Fast kinetics of electrochemical reactions lead to reduced electrochemical losses. Additionally, previous studies have shown that the efficiency of solid oxide cells can be significantly improved by operating at elevated pressure [1, 2]. A further reason for pressurization is the use of pressurized hydrogen in downstream processes like storage or fuel synthesis.

Experimental results of a SOEC stack operated under pressurized conditions in water electrolysis mode are presented. For a parameter study a commercially available planar stack consisting of 10 electrolyte supported cells was used. The stack was operated in a pressure range between 1.4 and 8 bar. Parameter sensitivities were examined by varying reactant gas composition (x_{H2O}=0.80…0.98), steam utilization (0.60…0.85) and operating temperature (750…850 °C). Pressure influence on open-circuit voltage (OCV) and reachable power density was examined on the basis of current-voltage curves. Impedance spectroscopy was carried out for further investigations to distinguish between different electrochemical phenomena. Whereas the impedance measurements show strong influences on several electrochemical and physical processes, current-voltage curves show only small changes due to the comparably low current densities reachable with electrolyte supported cells.

[1] S. Seidler, Journal of Power Sources Vol. **196**, 7195-7202 (2010)
[2] L. Bernadet, ECS Transactions Vol. 68, 3369-3378 (2015)