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Title: Analysis of Degradation Phenomena of SOC Stacks Operated in Reversible Fuel Cell / Electrolysis Mode

Abstracts (max. 270 words):

The reversible SOFC/SOEC operation of solid oxide cell (SOC) stacks promise high overall electricity-to-electricity round-trip efficiencies and low storage costs. Although in recent years the degradation rates of SOFC and SOEC stacks in single mode long-term operation have been steadily decreased, the understanding of degradation mechanisms during reversible SOFC/SOEC operation remains an important and challenging issue. Therefore, the Korean-German project “Solid Oxide Reversible Fuel Cell / Electrolysis Stack” (SORFES) focuses on the development of the core component technology for a 1 kW reversible SOC stack in order to enhance the hydrogen productivity and its utilization. The primary goals are the improvement of the performance and the durability of SOC stacks during reversible SOFC/SOEC operation and the quantification and the qualification of the relevant degradation effects.

The paper presents and compares the performance and degradation results of two SOC stacks which were operated mainly in galvanostatic steady-state SOFC mode and in reversible SOFC/SOEC cycling mode. The stacks with ASC cells of Elcogen (Estonia) were fabricated by the industrial project partner E&KOA (Daejeon, Korea). The reversible cycles consist of day/night switches between SOEC and SOFC, thus covering intermittent renewable electricity supply (e.g. of photovoltaics). The stacks were electrochemically characterized by jV-curves and electrochemical impedance spectroscopy (EIS).

The first SOC stack with 10 cells was operated during 500 h in SOFC at constant current density followed by 500 h of operation under reversible SOFC/SOEC cycling conditions. The initial performance and homogeneity along the repeat units (RUs) of the stack in SOFC and SOEC at the beginning of operation are presented. In order to better understand the stack degradation, the results between reversible SOFC/SOEC cycling and galvanostatic steady-state SOFC operation are compared. The degradation, especially of the OCV, the power density and the area specific resistance (ASR) of the different RUs are analyzed and discussed. Moreover, the progression of the individual resistances, specifically of the ohmic-, the electrode polarization- and the gas concentration resistances of the RUs are evaluated and presented. The influence of temperature gradients and thermo-mechanical stresses during reversible exothermic (SOFC) and endothermic (SOEC) cycling are outlined and discussed.

The results of the first stack test were used to improve the stack components and setup, e.g. the contacting and sealing of the cells in the stack and the protective coating on the interconnects. Moreover, the operating conditions during reversible SOFC/SOEC cycling were optimized. The second improved stack with 6 RUs was operated for 2800 h in galvanostatic steady-state SOFC mode and reversible SOFC/SOEC cycling mode with low degradation rate.

The results of the present paper help to understand and improve the long-term stability of SOC stacks during reversible SOFC/SOEC cycling, thus promoting the SOC technology for renewable energy storage applications.