Accelerated tests, early prediction and modelling tools

Accelerated lifetime testing for Solid Oxide Fuel Cells – anode degradation

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Life time evaluation for Solid Oxide Fuel Cells (SOFCs) is a time-consuming and expensive task. Low degradation rates of only a few mV per 1000 h, which are achieved for state-of-the-art cells [1] demand testing over several thousand hours to overcome the experimental error and to identify the major degradation mechanisms.

Among recent attempts to develop lifetime prediction models of SOFC was the European project 'EU SOFC-LIFE'. The aim of the project was to understand degradation by systematically testing single elements and interfaces of the interconnect-electrode-electrolyte-assembly, separately. The project revealed that the dominant contribution affecting degradation of single repeating units (SRU) is due to an increased contact resistance of the cathode/interconnect interface. Unfortunately, the project could not succeed in relating degradation phenomena of isolated elements to the total SOFC or SRU unit [2].

It is therefore highly desirable to develop a testing strategy to predict the durability of the complete SOFCs in a fast and still appropriate manner. Accelerated lifetime testing (ALT), as a possible method, is conducted by provoking degradation under heavy-duty operating conditions ideally without causing any new failure processes [3]. However, it is challenging to choose relevant aggravated operating conditions for SOFCs, as degradation mechanisms of SOFC components (i.e. cathode, anode and electrolyte) show different dependencies on parameters such as temperature, current load or fuel composition. Even though major failure mechanisms are known, no general agreement has been reached regarding which degradation phenomena dominates the overall cell degradation and even less how it can be accelerated in appropriate way by different testing conditions.

These considerations motivated a detailed analysis of approx. 180 durability tests regarding degradation of single SOFC components as function of operating conditions [4]. Electrochemical impedance data were collected on the fresh and long-term tested SOFCs and used to de-convolute the individual losses of single SOFC cell components – electrolyte, cathode and anode. The main findings include a time-dependent effect on degradation rates and the domination of anode degradation for the evaluated cell types and operating conditions. Specifically, the steam content as determined by fuel inlet composition, current density and fuel utilization was identified as major parameter, more important than for example operating temperature. The obtained knowledge is adopted to identify optimal operation profiles in order to acquire accelerated testing for lifetime investigation of SOFCs.

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