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SOLID OXIDE CELL AND STACK TESTING, SAFETY AND QUALITY ASSURANCE (SOCTESQA)

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Abstract - **For the successful market penetration of high temperature solid oxide fuel/electrolysis cell energy systems it is necessary to increase the quality assurance and the reliable assessment of the corresponding cells and stacks. Therefore in May 2014 the EU-funded project "SOCTESQA" was launched. The aim is to develop uniform and industry wide test programs for solid oxide cell/stack (SOC) assembly units. The paper presents the results which have been achieved so far, e.g. the development of a test matrix and of generic test modules for current-voltage curves, electrochemical impedance spectroscopy and long term tests. Several of these test modules were combined to a test program and applied by the different partners to an SOC stack. The test output results (TOPs) are compared to each other and possible differences are discussed in context to differences in test input conditions (sensitivity analysis). This validation process helps to improve the generic test modules and programs.**

Index Terms – **quality assurance, solid oxide cell/stack, standardization, test program**

I. INTRODUCTION

High temperature solid oxide assembly units and the appendant test systems are very complex in structure and processing. There are many parameters which influence the test results and therefore have to be considered during testing. In order to simplify and harmonize test programs among different research facilities, laboratories and developers detailed test schemes, programs and protocols are necessary - mainly as there is an increasing amount of application fields which are based on the operation of SOC cell/stack assembly in the fuel cell (SOFC), in the electrolysis (SOEC) and in the reversible SOFC/SOEC mode. The "SOCTESQA" project focuses on the development of robust and uniform test programs for experimental characterization of the specified SOC test object and the interpretation of measured data (Figure 1). The project builds on experiences of previous and ongoing EU-projects, e.g. "FCTESTNET" [1], "FCTESQA" [2] and "STACKTEST" [3] but also on the activities of relevant standards developing organizations, e.g. the International Electrotechnical Commission (IEC) [4].

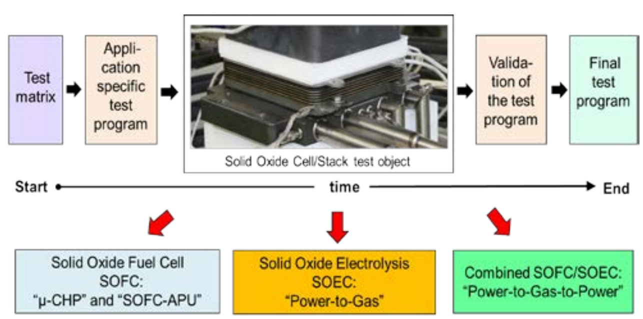

Fig. 1. Scheme of project objective

II. TEST MATRIX

A test matrix was developed which includes possible characterization methods, so called test modules (TM), covering the wide range of applications e.g. stationary SOFC µ-CHP, mobile SOFC APU and SOFC/SOEC power-to-gas systems. Altogether 18 test modules were specified. Important test modules are current-voltage curves, electrochemical impedance spectroscopy and long term tests under steady state or dynamic operating conditions.

III. INTERFACES BETWEEN TEST OBJECT AND TEST ENVIRONMENT

Special attention has to be paid on the interfaces between test object (SOC stack) and test environment (Figure 2). These interfaces can be separated in media, electric, heat and mechanical nature. Moreover the test input parameters (TIPs) and test output parameters (TOPs) at the interfaces have to be defined clearly. In the “SOCTESQA” project TIPs are defined as parameters whose values can be set in order to define the test operating conditions of the cell/stack. TIPs have to be controllable and measurable. On the other hand TOPs are parameters that indicate the performance of the cell/stack as a function of TIPs. Variation of TIPs leads to a response of the cell/stack indicated by the change of TOPs. TOPs do not have to be controllable but must be measurable.

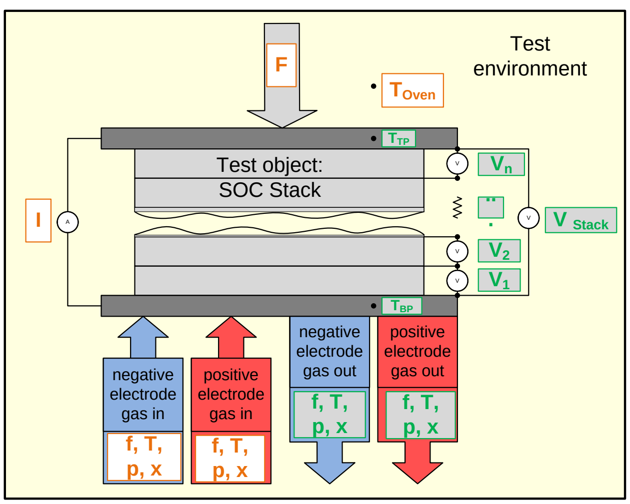

Fig. 2. Interfaces between SOC stack test object and test environment

IV. TEST PROGRAM

Fig. 3 shows a possible test program for durability testing as an example. It consists of a series of different test modules for characterization and performance evaluation, each module with its own specific objective as well as the test program objective. The initial and final current-voltage curve (TM02) qualifies the initial and final performance. To identify the performance-limiting factor as well as the degradation mechanism the electrochemical impedance spectroscopy (TM03) is a useful tool. The applied test modules define the key parameters such as the current variation rate, gas flow rates, gas and stack temperatures, frequency range, excitation amplitude etc. as well as the way to present the data. Many applications require long term stable operation either under steady state or dynamic operation conditions. This issue is covered by the test modules “Operation under constant current” (TM12) and “Operation under varying current” (TM13), respectively.

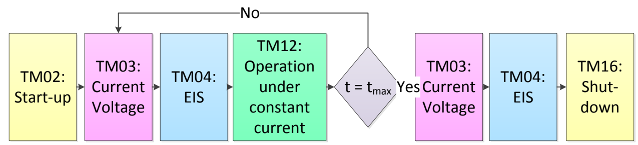

Fig. 3. Example of a test program for an SOC stack test object

This test program is currently applied by the different partners to identical SOC stacks and the results are compared to each other. With this review and validation loop the test modules and program are further optimized.

V. CONCLUSION

The proper definition and the monitoring of all interfaces between short stack and test station are very important. The first results between the partners show a high consistency. A high sensitivity of the stack behavior towards operating temperatures and the process gases was found. These high sensitivity parameters have to be addressed properly in the test modules and programs.

ACKNOWLEDGMENT

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