RECENT RESULTS OF STACK DEVELOPMENT AT FORSCHUNGSZENTRUM JÜLICH

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Since the mid-nineties several generations of SOFC stacks have been designed and tested incorporating the anode substrate-type cells developed in Jülich. The 5th generation, the so-called E-design stacks, with metallic interconnect constitutes the ‘work horse’ used for testing materials, cells and manufacturing processes in cell and stack development since its introduction in the year 2000 (1). A 40-layer stack (40 cells of 20 x 20 cm²), manufactured according to the E-design, was put into operation in mid-April 2002. All ferritic parts were made of the commercial steel type 1.4742. The stack delivered 9.2 kW_{el} in operation with hydrogen and 5.4 kW_{el} with methane as fuel (2). Whilst a small fraction of hydrogen was added to simulate pre-reformed natural gas, the stack nevertheless operated at approx. 100% internal reforming. The stack was run with a constant current density of 0.5 A/cm² for the first 1000 h of continuous operation (see Fig. 1). After a reduction of the furnace temperature the stack continued to operate in thermal self-sustaining mode, still producing between 4.0 and 4.5 kW_{el} with methane as fuel. Current density was lowered to 0.3 A/cm² after 1000 h, until it was switched off after a total of approx. 1250 h. Average degradation was in the range of 10%/1000 h at an average temperature below 850 °C, typical for the unprotected ferritic steel 1.4742.

A series of E-design short-stacks (2 cells 10 x 10 cm²) was assembled with interconnects manufactured from a modified ferritic steel coded JS-3 (1,3). The ceramic cathode contact layer LCC2 was developed for this type of interconnect (1,4). Fig. 2 shows the time dependence of one of these short-stacks during operation with hydrogen at 0.3 A/cm² and 800 °C. The stack was operated over 4000 h with a degradation rate for both cells between 2 and 3%/1000 h.

A further short-stack, also with JS-3 interconnects, was subjected to a total of 40 thermal cycles after an initial period of 1800 h of galvanostatic operation. As can be seen in Fig. 3 the degradation rate, initially also around 2-3%/1000 h, was not noticeably affected by the repeated thermal cycles.

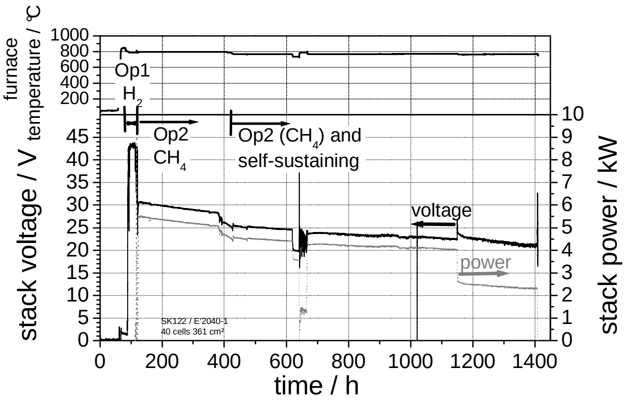

Fig. 1: Time dependence of the stack voltage and power of the 40-layer E-design stack operating on CH_4/H_2O, producing between 4.0 and 5.5 kW_{el}.

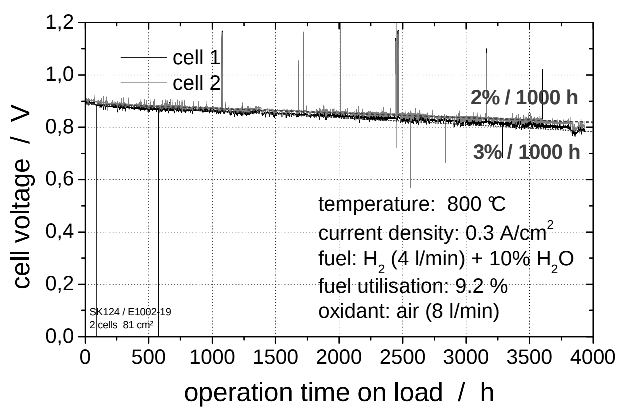

Fig. 2: Time dependence of the cell voltages in a 2-layer E-design short-stack with JS-3 interconnects during operation with H_2 at 800 °C and 0.3 A/cm².

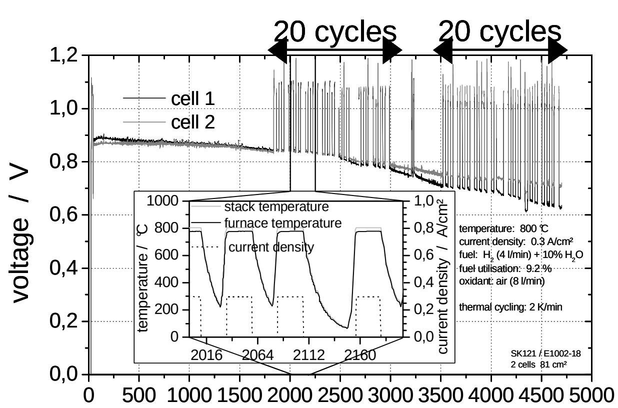

Fig. 3: Time dependence of the cell voltages in a 2-layer E-design short-stack subjected to multiple thermal cycles from 800 °C to 220 °C/75 °C.

REFERENCES

(1) L.G.J. de Haart, I.C. Vinke, A. Janke, H. Ringel and F. Tietz, in *Solid Oxide Fuel Cells VII*, H. Yokokawa and S.C. Singhal, Editors, **PV 2001-16**, p. 111, The Electrochemical Society Proceedings Series, Pennington, NJ, (2001)

(2) L. Blum, L.G.J. de Haart, I.C. Vinke, D. Stolten, H.-P. Buchkremer, F. Tietz, G. Blaß, D. Stöver, J. Remmel, A. Cramer and R. Sievering, in *5th European Solid Oxide Fuel Cell Forum*, J. Huijsmans, Editor, **Vol. 2**, p. 784, European Fuel Cell Forum, Oberrohrdorf (2002)

(3) J.P. Abellán, V. Shemet, F. Tietz, L. Singheiser, W.J. Quadakkers and A. Gil, in *Solid Oxide Fuel Cells VII*, H. Yokokawa and S.C. Singhal, Editors, **PV 2001-16**, p. 811, The Electrochemical Society Proceedings Series, Pennington, NJ, (2001)

(4) O. Teller, W.A. Meulenberg, F. Tietz, E. Wessel and W.J. Quadakkers, in *Solid Oxide Fuel Cells VII*, H. Yokokawa and S.C. Singhal, Editors, **PV 2001-16**, p. 895, The Electrochemical Society Proceedings Series, Pennington, NJ, (2001)