STRENGTH OF PLANAR CELLS FOR SOFC APPLICATION

J. Malzbender, R.W. Steinbrech, L. Singheiser
Forschungszentrum Jülich GmbH
Institute for Materials and Processes in Energy Systems
52425 Jülich

The properties of SOFC components receive increasing interest due to the scale up of SOFC cells and stacks and the attempts to improve the long term performance [1]. Although the main factors influencing the design are electro-chemical nature, the requirement to operate the components at relatively high temperatures and the need for thermal cycling between room and the operation temperature makes thermomechanical aspects of the components extremely important [2].

Various investigations on the mechanical properties of SOFC materials exist, but the number of studies on actual cells is still limited [3,4]. In this paper an investigation on the modulus of rupture of SOFC cells is presented. Specimens of three planar cell variants with different total thickness (~ 0.25 - 1.5 mm), thin electrolyte (~ 10 µm) and proprietary microstructure and composition, have been tested. Both, cells with anodes in oxidised and reduced state were examined.

The bending tests were performed with the surface of the anode either in tension or in compression, using a four-point bending and ring-on-ring loading device for the thick and thin cells, respectively. The experimental fracture loads (Fig. 1) are analysed considering the effect of the flexural rigidity of the multi-layered composite, the distance of the failure origin from the neutral axis and the development of residual stresses in the multilayer cell composite. Fracture mechanics provide information about the microstructural defect sizes. The extension from specimen data to the strength of cell components is achieved by applying statistical approaches.

Thermal mismatch stresses influence fracture stress and failure origin. At room temperature the thin electrolyte experiences large compressive stresses (Fig. 2). Thus even when a bending stress is applied with the electrolyte in tension, the failure causing crack does not necessarily initiate there. Lower fracture loads are measured for the anode in tension compared to electrolyte in tension at RT for oxidised cells, independent of the anode thickness (Fig. 1). Measurement of the fracture loads for oxidised cells at 800°C or cells with reduced anodes at RT lead to an increase of the fracture load of the anode in tension as compared to the electrolyte in tension. It is discussed how these observations are related to changes in residual stress, flexural rigidity and neutral axis. Considering the statistical scatter of the Modulus of Rupture (MOR), as assessed by Weibull statistics with modulus *m*, the decrease of the fracture stress for larger cells can be predicted too (Fig. 3).

References

1) S.C. Singhal, Solid State Ionics 135 (2000) 305.
2) S.P.S. Badwal, Solid State Ionics 143 (2001) 39.
3) B.F. Soerensen, S. Primdahl, J. Mater. Sci. 33 (1998) 5291.
4) A. Selcuk, G. Merere, A. Atkinson, J. Mater. Sci. 36 (2001) 1173.

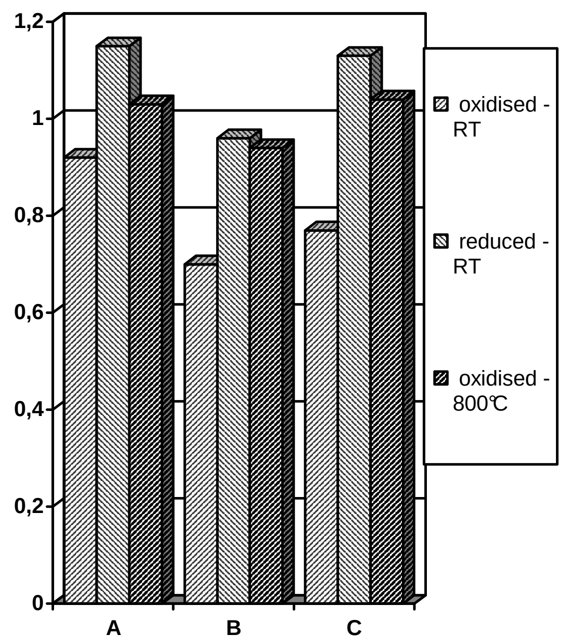

Fig.1. Normalised experimental fracture loads for variants A - C. Shown is a comparison of results for anode in tension to electrolyte in tension.

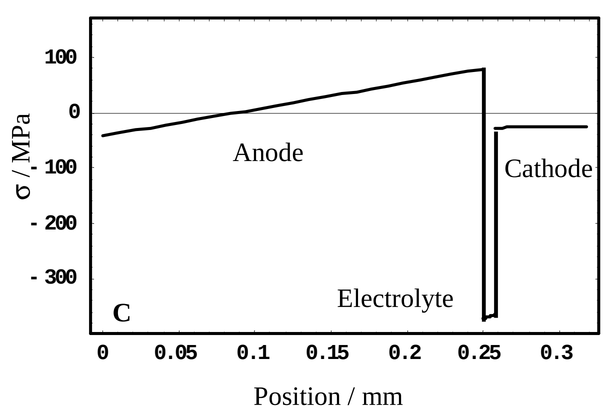

Fig.2. Example of the residual stresses in a SOFC cell (variant C).

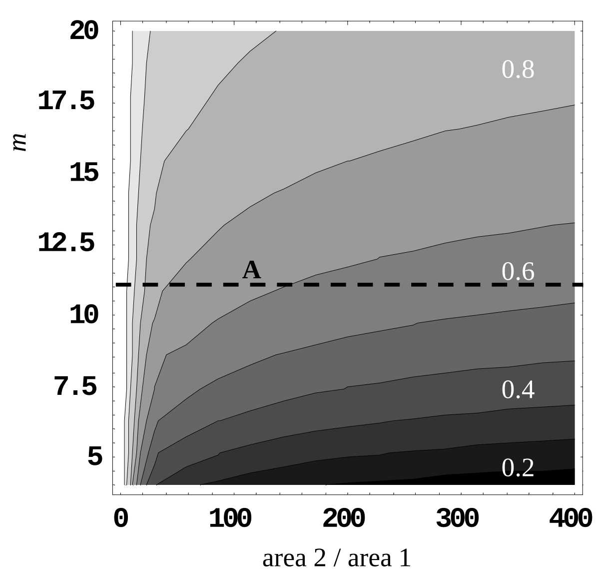

Fig.3. Effect of the Weibull modulus, *m* and ratio of cell component size (2) to tested specimen area (1) on the MOR. The strength reduction curves are plotted.