# ISSUES AFFECTING THE MECHANICAL INTEGRITY OF SOFCS

**Samuel T Hagos, Rowland P Travis**
Mechanical Engineering Department,
Imperial College London
Exhibition Road, London SW7 2BX, UK

The elevated operational temperature of a Solid Oxide Fuel Cell (SOFC) means that the cell components are subject to a number of issues affecting their mechanical integrity within the composite structure. These include residual stresses due to thermal expansion mismatch of the components, thermally induced stresses, and material creep at the elevated temperature. Half cells made of a standard Yttria Stabilized Zirconia (YSZ) electrolyte substrate coated with an anode or cathode were specially prepared for the residual stress and creep analysis, and a porous support material was tested to fracture under thermally induced stresses. The creep deflection of the coated material was observed to be greater that that of the corresponding plain YSZ under the same temperature and stress conditions. Results of residual stress measurements based on curvature measurement were also found to be significantly lower than the predicted Finite Element stresses. The porous support exhibited good resistance to thermal stresses.

The present investigation arose from the observation that there is little information available on the mechanical behaviour of SOFC components. The bulk of the research work on fuel cells in general has focussed on the electrochemical performance rather than mechanical integrity. However, mechanical and electrochemical requirements in a cell can be in direct conflict. High working temperature can result in material constraints and integrity issues. For example, temperatures and stresses which are within the conditions known to cause creep in these materials are known to be present.

The aim of this paper is to assess some of the factors affecting the mechanical integrity of a SOFC. The issues identified here are (i) residual stresses due to thermal expansion mismatch during cooling after manufacture; (ii) creep due to the high working temperature, and (iii) thermally induced stresses due to temperature variations.

The results of this work were: the residual stresses of electrolyte-coated YSZ were evaluated. They are considerably less than a simple thermoelastic analysis would suggest. Secondly, the time dependent deflection of anode-coated YSZ material was observed to be significantly greater than the corresponding plain YSZ under the same stress and temperature conditions. The residual stresses on the electrolyte-coated YSZ samples at room temperature were observed to reduce, and some of this stress relaxation was caused by creep. However, predictable Coble creep does not appear to account for majority of the stress relaxation. It is concluded therefore that either there is some other stress-reduction mechanism apparent between YSZ and anode layers in SOFCs. Finally, a method for establishing material properties under thermal stress is briefly presented, and a porous substrate is shown to withstand designed temperature distributions.

| Sintering Temperature | Residual Stress [MPa] | Estimated thermoelastic stresses [MPa] |
|---|---|---|
| 1025°C | 0.44 | 49.8 |
| 1125°C | 0.91 | 54.8 |

**Table I. Estimated residual stresses from curvature measurement and FE analysis of a cathode-YSZ bi-layer.**

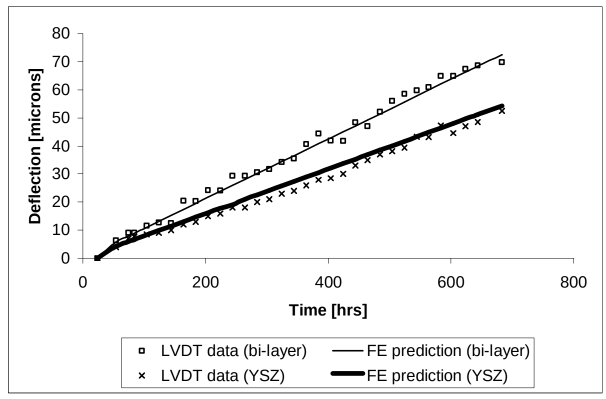


**Figure 2 – Deflection of YSZ and anode- coated YSZ in a ring-on-ring biaxially loaded creep test.**

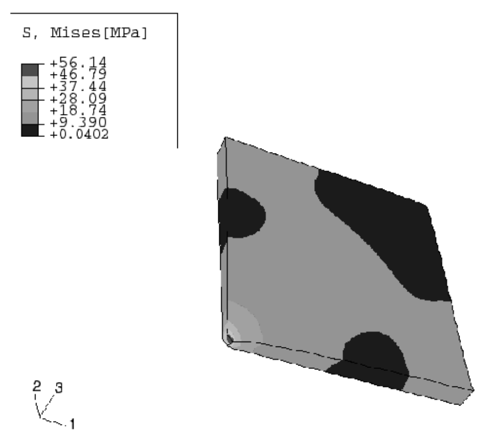


**Figure-5 Stress distribution at failure caused by thermally induced stresses**