Dimensional Change *In Situ* for SOFC Stack Manufacturing

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Introduction

The importance of cost reduction during the manufacture of planar geometry fuel cells has been well demonstrated. SOFC stacks usually consist of anode supported single cells alternated with a seal material to separate the reactant and product gases. The dimensional behavior of these seals during heating is an area of particular importance as it is widely known that failure during rapid thermal cycling occurs in the seals. In addition, nickel oxide reduction/oxidation cycling and other dimensional changes can occur during use and these could very likely have an impact on the total lifetime of the stack. We also have a strong interest in surface curvature and how this governs the yield of the manufacturing processes and how it might reflect stack-based stresses that lead to failure.

We have used an optical profilometer to quantitatively describe surface curvature, inherent defects and overall morphologies in laminated electrodes, applied electrolyte coatings and screen printed fuel cell components. However, a laser dilatometer adapted to study the relative behavior of the individual stack components in situ has been more useful in that it appears capable of detecting (1) the absolute shift of each component in a stack, (2) the dimensional behavior of the constrained seal and (3) how curvature and seal maturation interact.

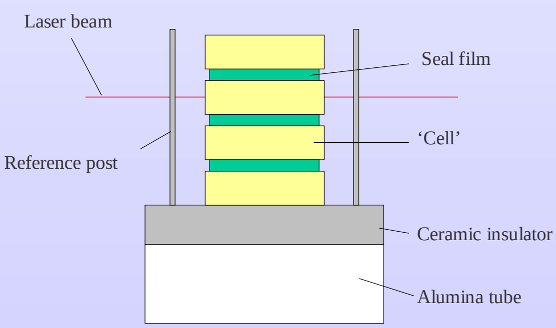
Objectives

1. Examine the dimensional evolution of a seal inside a stack during both the initial heating and a subsequent thermal cycle.
2. Determine whether the position of each 'cell' in a stack can shift during heating.
3. Determine surface curvature in an individual 'cell' before and after sealing. Does surface curvature influence seal maturation?
4. Establish the contribution of NiO reduction to post-sealing curvature.

Materials and Methods

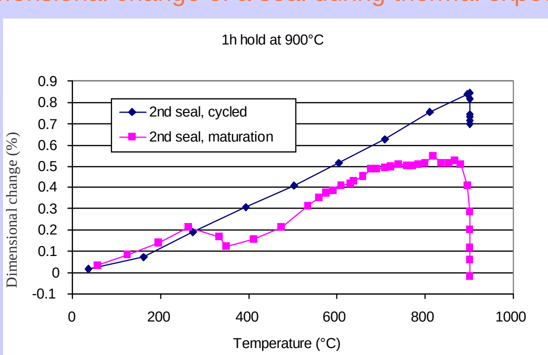
- YSZ/NiO anode discs* 1" in diameter were used to construct a 'stack.'
- A seal** having an OD of 20 mm and an ID of 10 mm was used to seal the 'cells.'
- *Heating*: 2°C/min to either 825°C or 900°C for 1-2 hrs followed by a furnace cool
- *Reduction*: 2°C/min to 600°C for 2 hrs at atmosphere of 5% H_2+95% N_2.

Schematic of the 'stack' inside the laser dilatometer

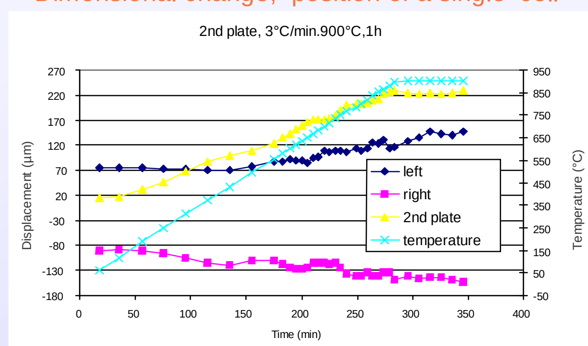


Results

Dimensional change of a seal during thermal exposure



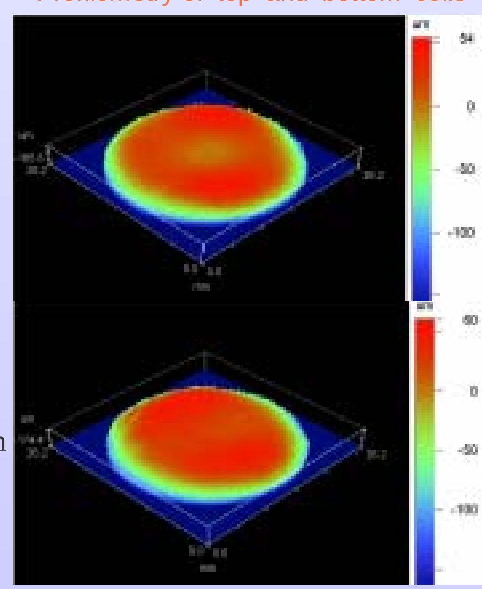
Dimensional change, position of a single 'cell'



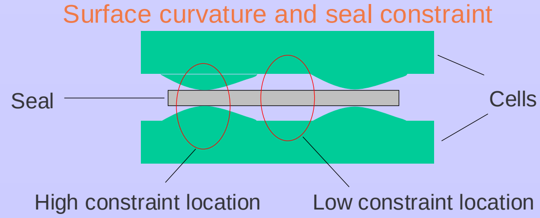
Does surface curvature matter? Profilometry of 'top' and 'bottom' cells

Top

Bottom



Surface curvature and seal constraint



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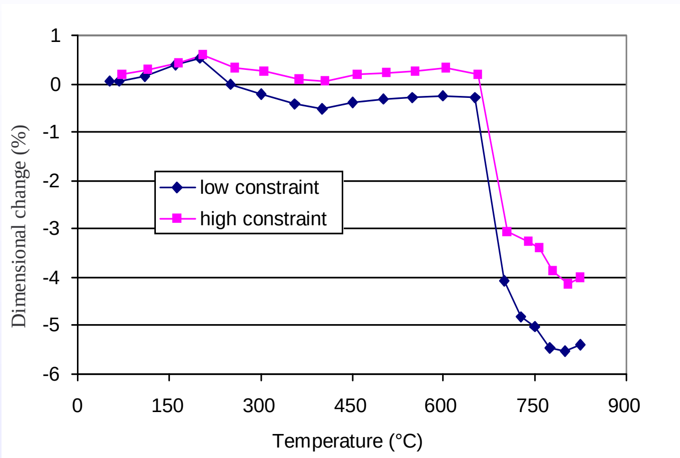
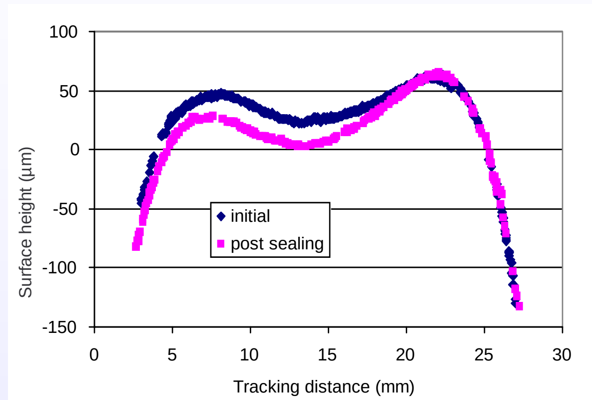
In-situ dimensional change of a seal



Curvature of the top cell before and after sealing*



Top cell, high constraint location

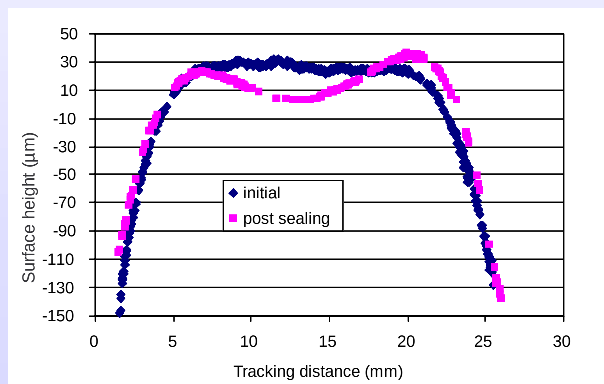
In-situ determination of thermal expansion coefficients

Rather than rely on thermal expansion coefficients either collected from the literature or generated in a separate contact dilatometer experiment, the laser dilatometer allows us to examine the thermal expansion of each component in the stack. This allows incorporation of the 'real' dimensional behavior which could conceivably include other influences.

As the 'stack' was cycled to 825°C, no significant difference in the thermal expansion of either the cell or the seals was observed between the low and high constraint areas. Thermal expansion coefficients (TEC's) were calculated for both the seal and the cell based on cycled measurements:

For the seal: 1.4×10^{-5} /°C

For the 'cells': $1.2\text{-}1.7\times10^{-5}$ /°C



Top cell, low constraint location

***Results verified by repetition.**

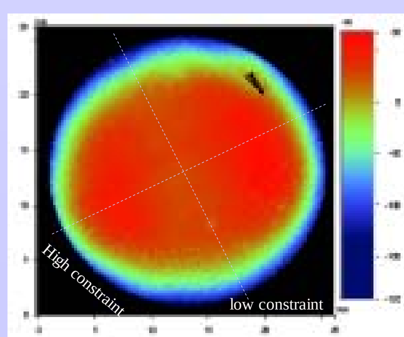
The curvature of the bottom cell did <u>not</u> change during this cycle.

The curvature of the cells post reduction was also measured; no significant changes were observed in either the top or the bottom cell.

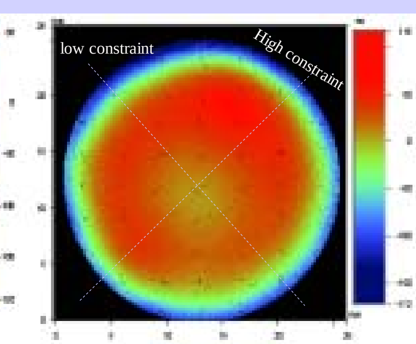
Conclusions

These 'cells' consisted only of only the YSZ-NiO anode. No electrolyte or cathode was present. This eliminated any effect of thermal expansion mismatch.

1. Laser dilatometry can successfully monitor both seal and cell motion.
2. Seal maturation can depend on local cell curvature.
3. The curvature of the top cell changed in both directions during sealing.
4. The curvature of the bottom cell was unchanged.
5. Neither seal cell exhibited changes in curvature after reduction.



Initial



Post sealing