Proton Conductor Based Solid Oxide Fuel Cells

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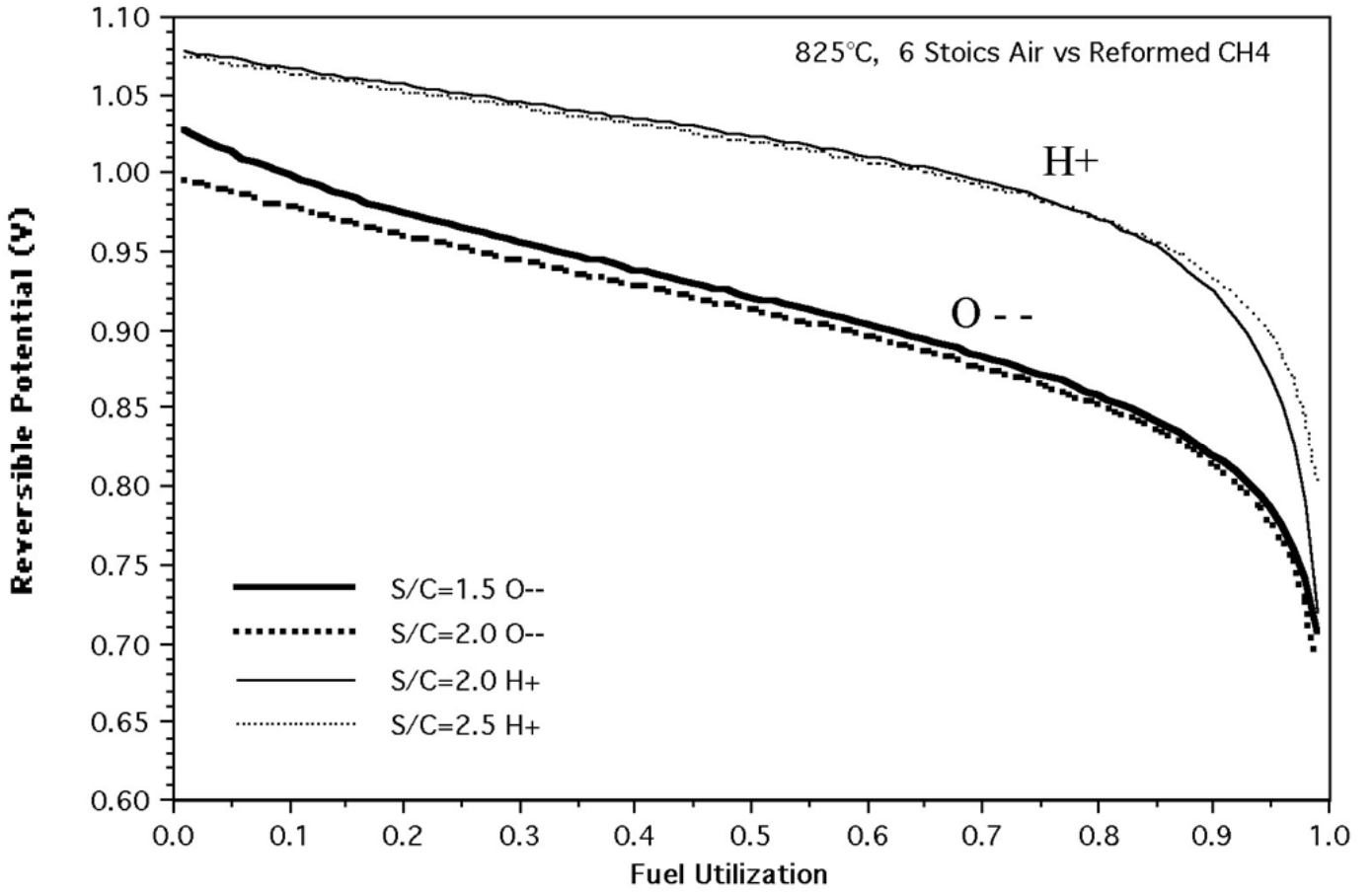
Outline

- Thermodynamic Analysis Shows Higher Efficiency for Proton Cells compared to Oxygen Cells
- Stability addressed by the use of composite electrolyte
- Anode supported composite electrolyte cell shows good performance
- Stability in high CO_2 containing fuel demonstrated

Driving Force Comparison

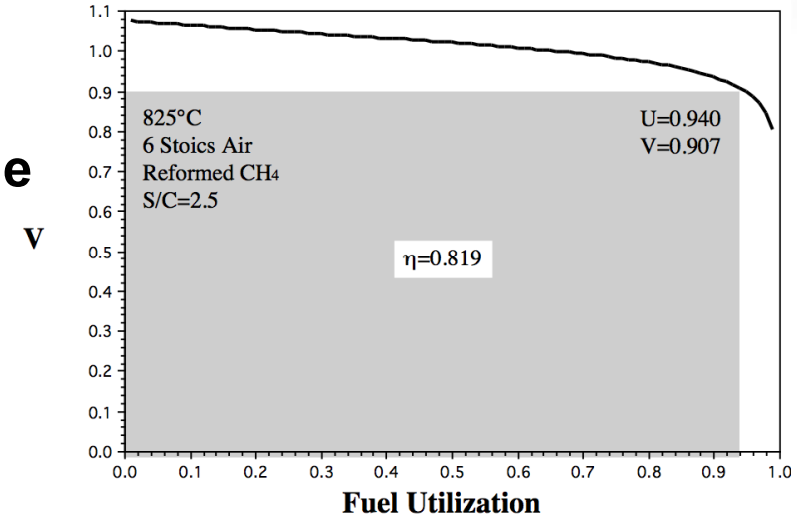


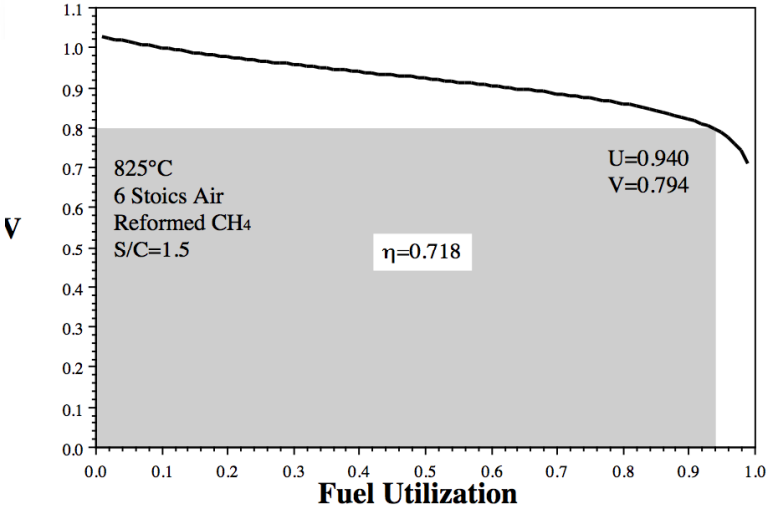
- High driving force even at high fuel utilization

Max. Efficiency Comparison

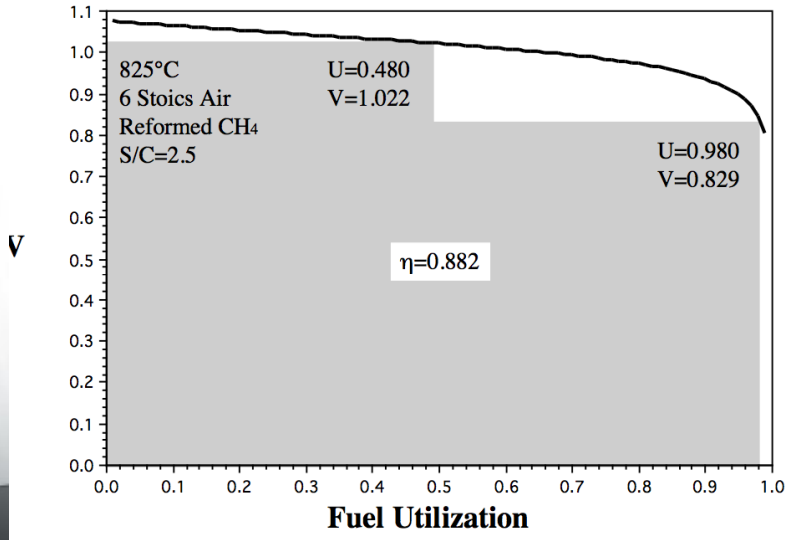
- **Proton Cell**
- **Oxygen Cell**

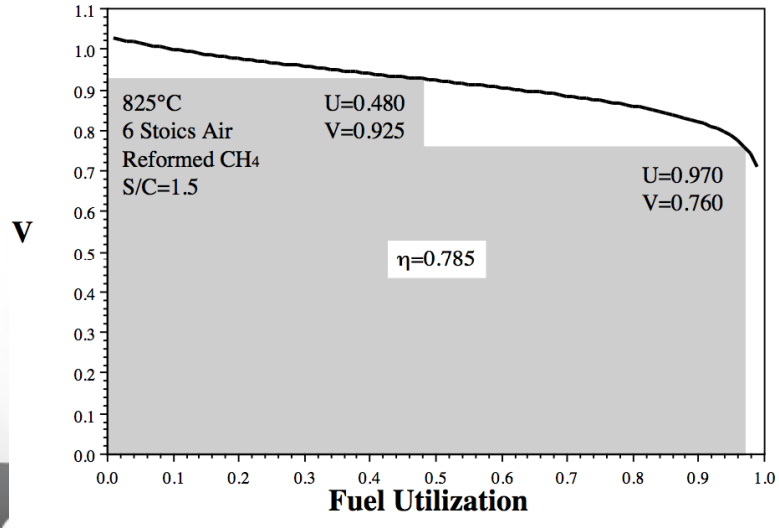
Single Stage



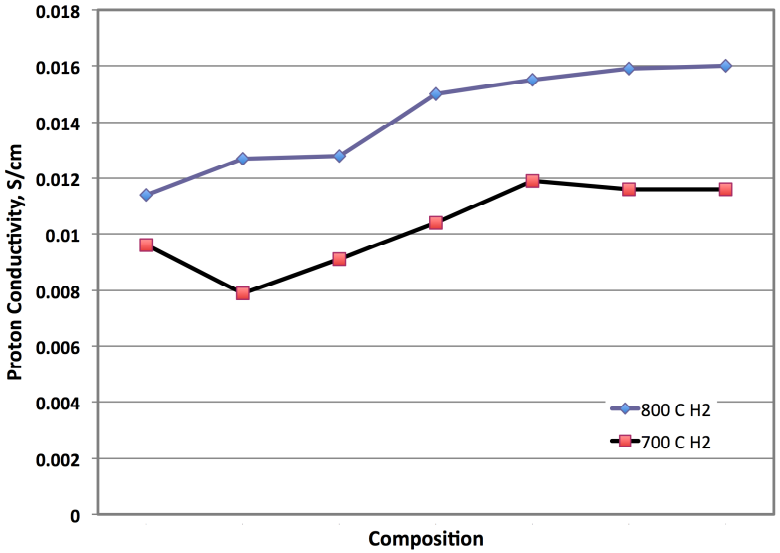


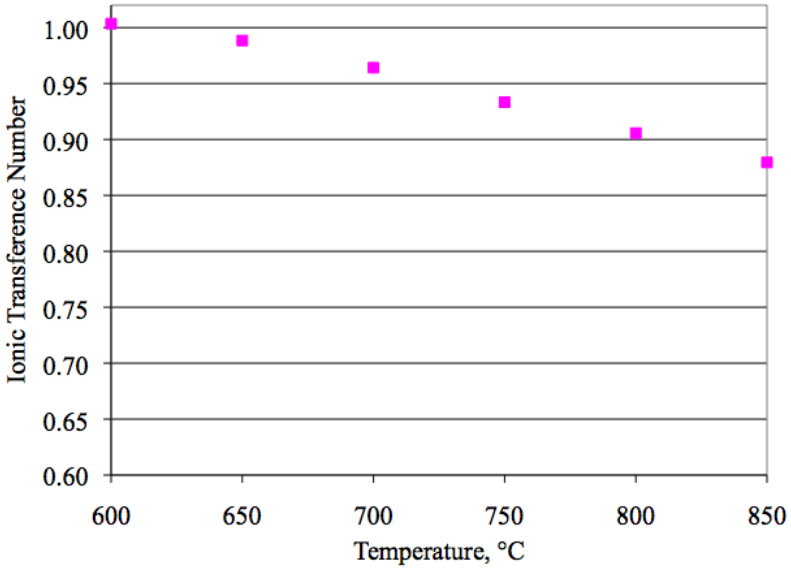
Two Stage





$BaCeO_3$ Proton Conductivity and Transference Number

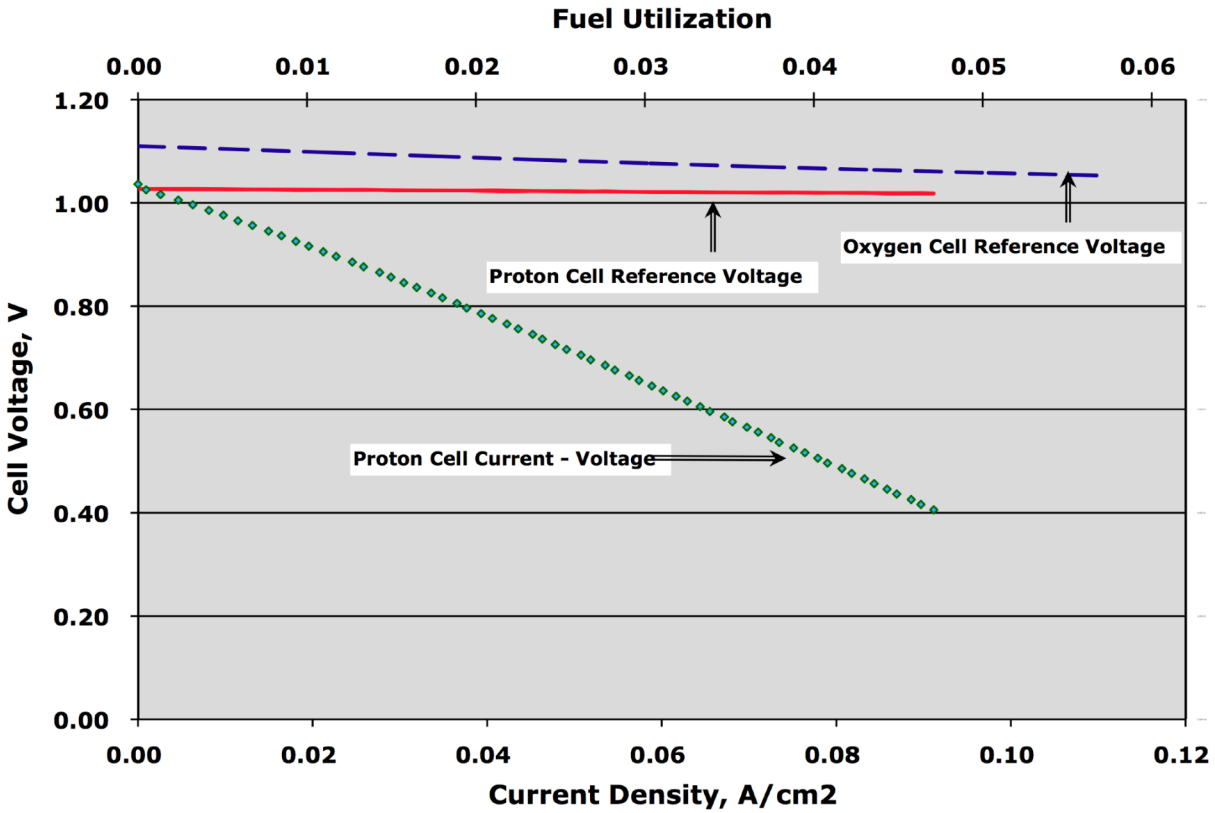




- Highest conductivity range from 0.01 to 0.016 in 700° to 800°C range
- ~ half the oxygen ion conductivity of 8YSZ
- Ionic transference number >0.95 at 700°C

Comparison of Driving Force

0.5 mm thick pellet of BCY (800°C)



- Proton cell shows negligible change in driving potential compared to Oxygen cell
- Even with lower OCV, the Nernst potential crosses over at utilization of >10%

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Instability of Perovskite

- Stability of $BaCeO_3$ in hydrocarbon based fuel is a major known issue

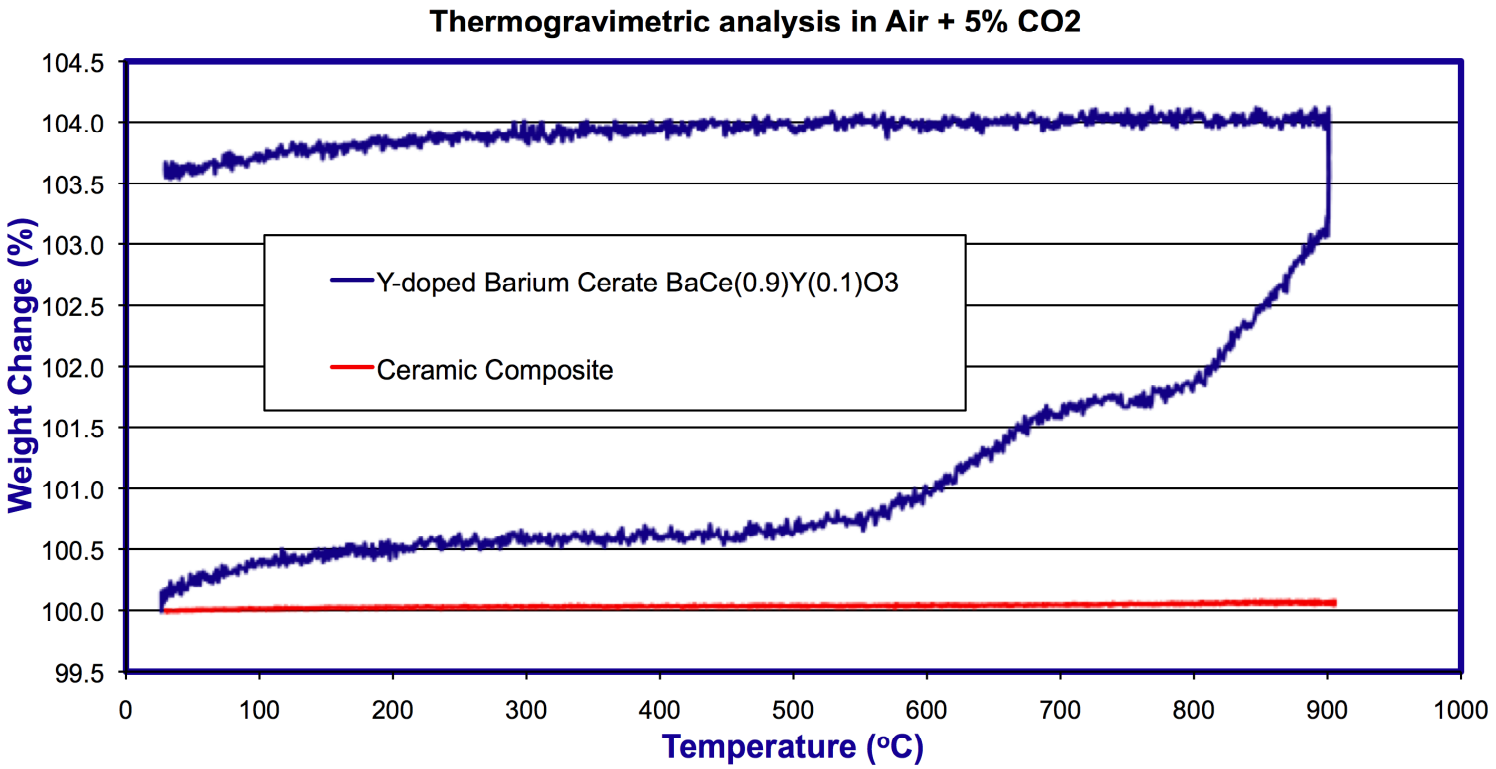
$$BaCeO_3 + CO_2 = BaCO_3 + CeO_2$$

$$BaCeO_3 + H_2O = Ba(OH)_2 + CeO_2$$

Composite of BCY + YDC for Improved Stability

Enhanced Thermochemical Stability

Ceramic Composite over BCY



- **Stability in CO_2+Air mixture (TGA)**
  - **BCY + YDC (crushed sintered disk)**

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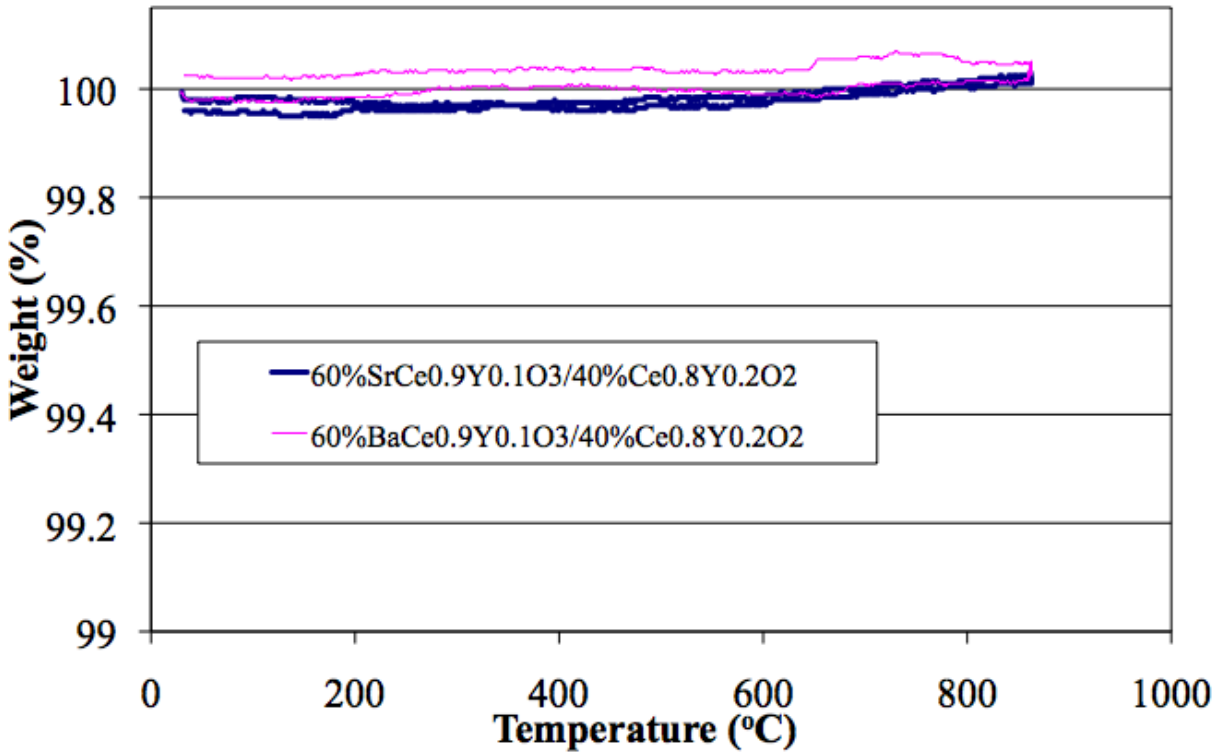
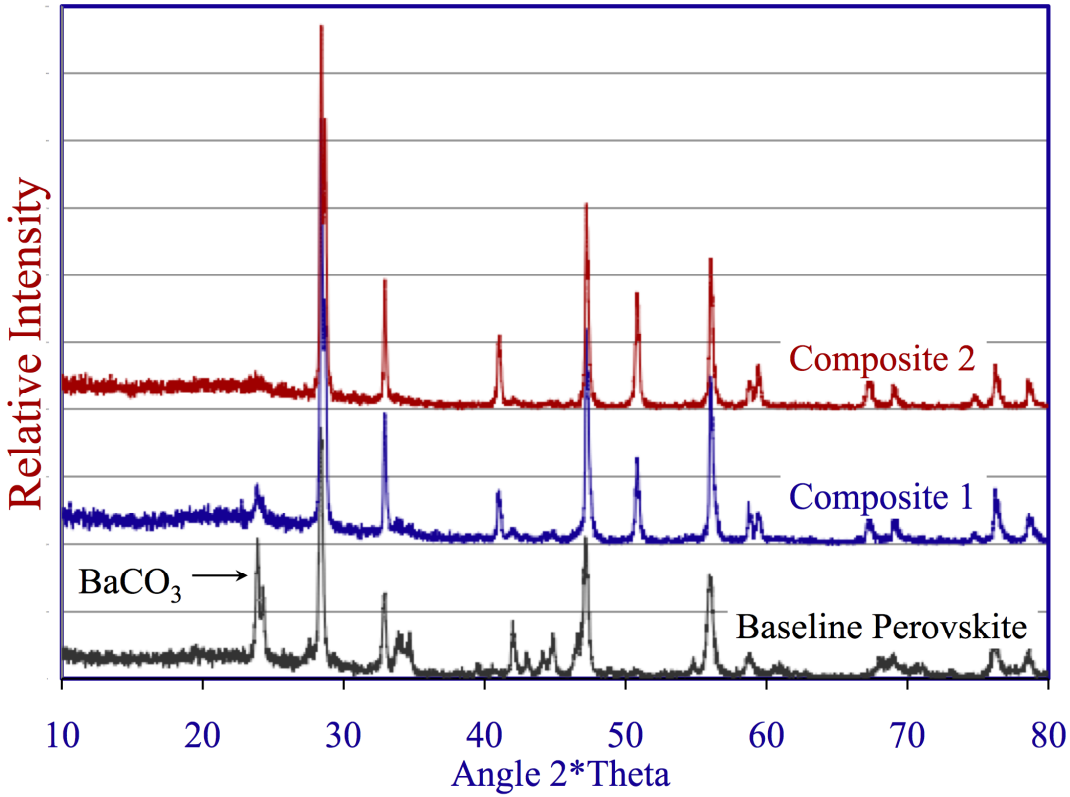
Composite Stability in Syngas



- **Stability in CO-CO_2-H_2-H_2O mixture**

$BaCeO_3$ vs Composite Stability



- Exposure to syngas at 900°C

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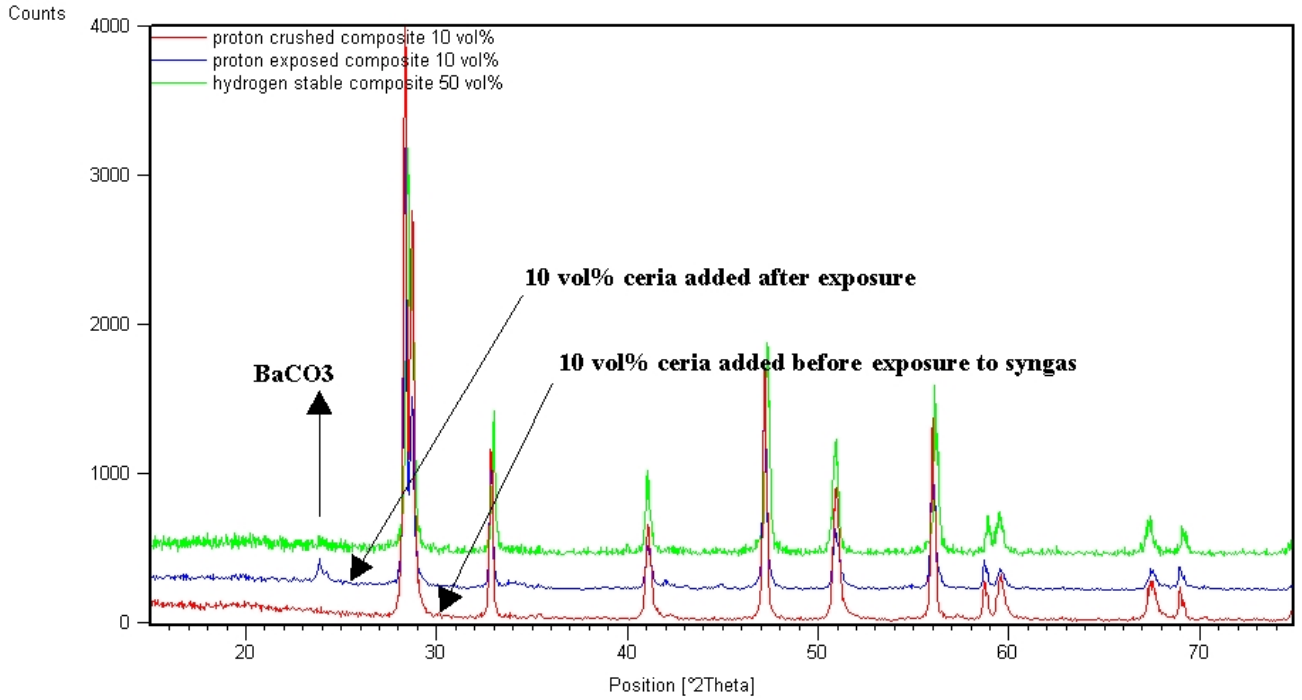
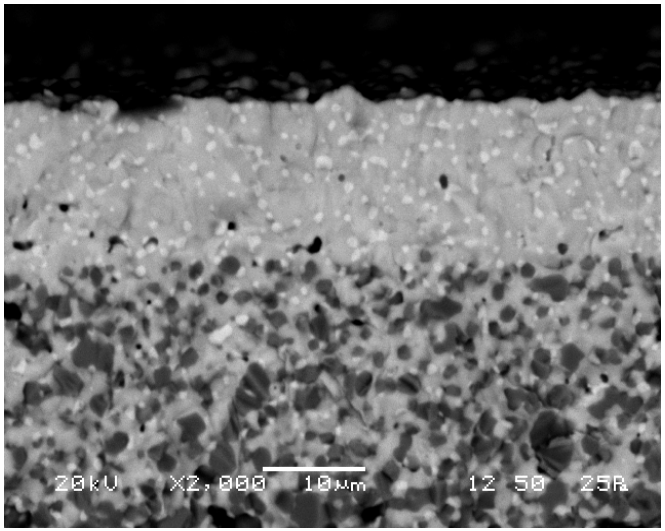
Exposure to Syngas at 700°C



- As low as 10 vol% Ceria shows improvement in stability

Anode supported thin film cell

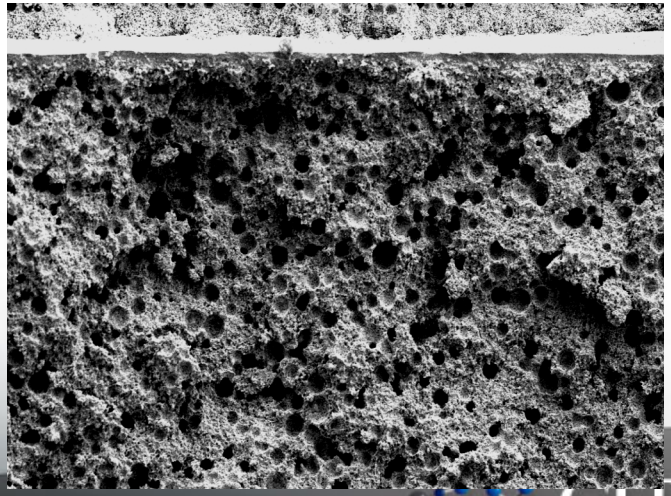
Cell before testing



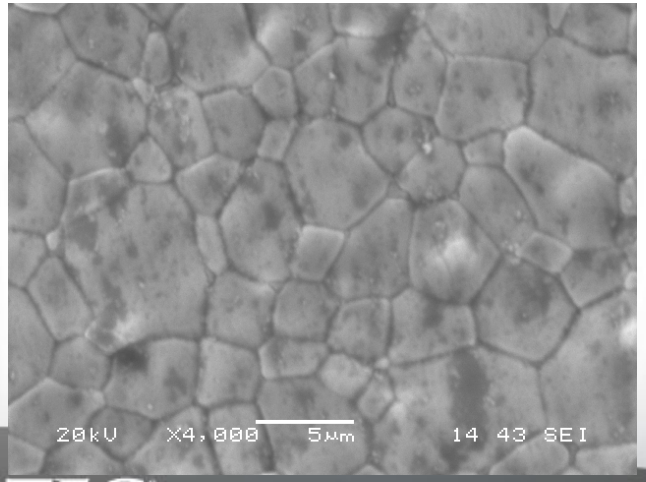
Dense thin film (~15 µm) BCY+YDC composite electrolyte

Anode: 50 wt% NiO and 50 wt% (BCY+YDC)

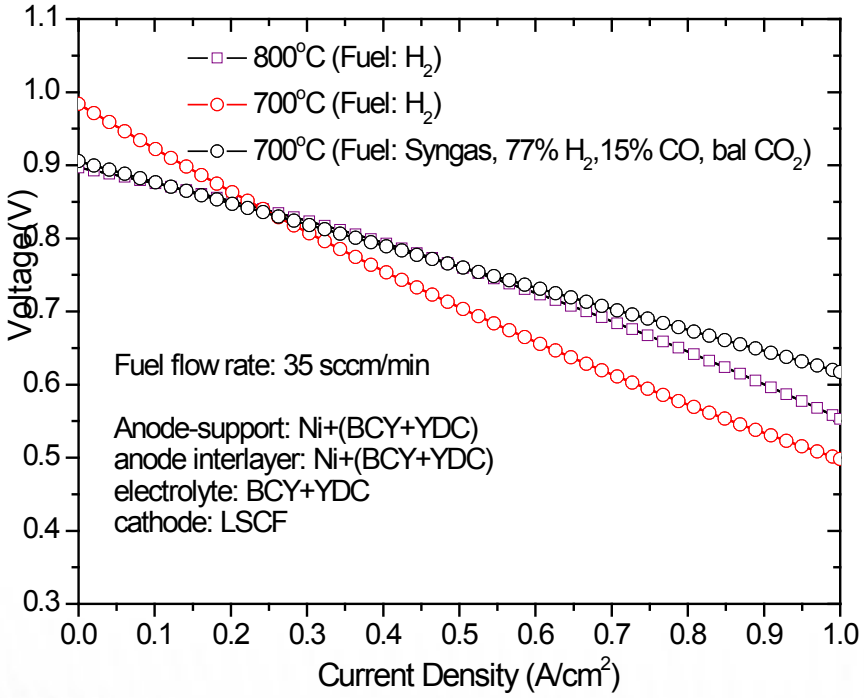
Cell after testing

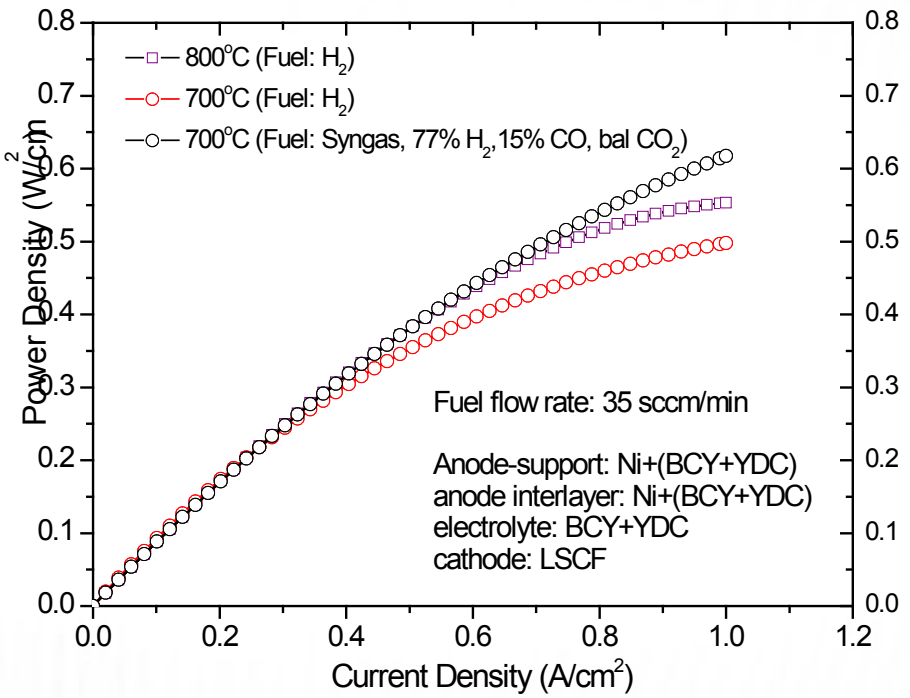


Electrolyte surface

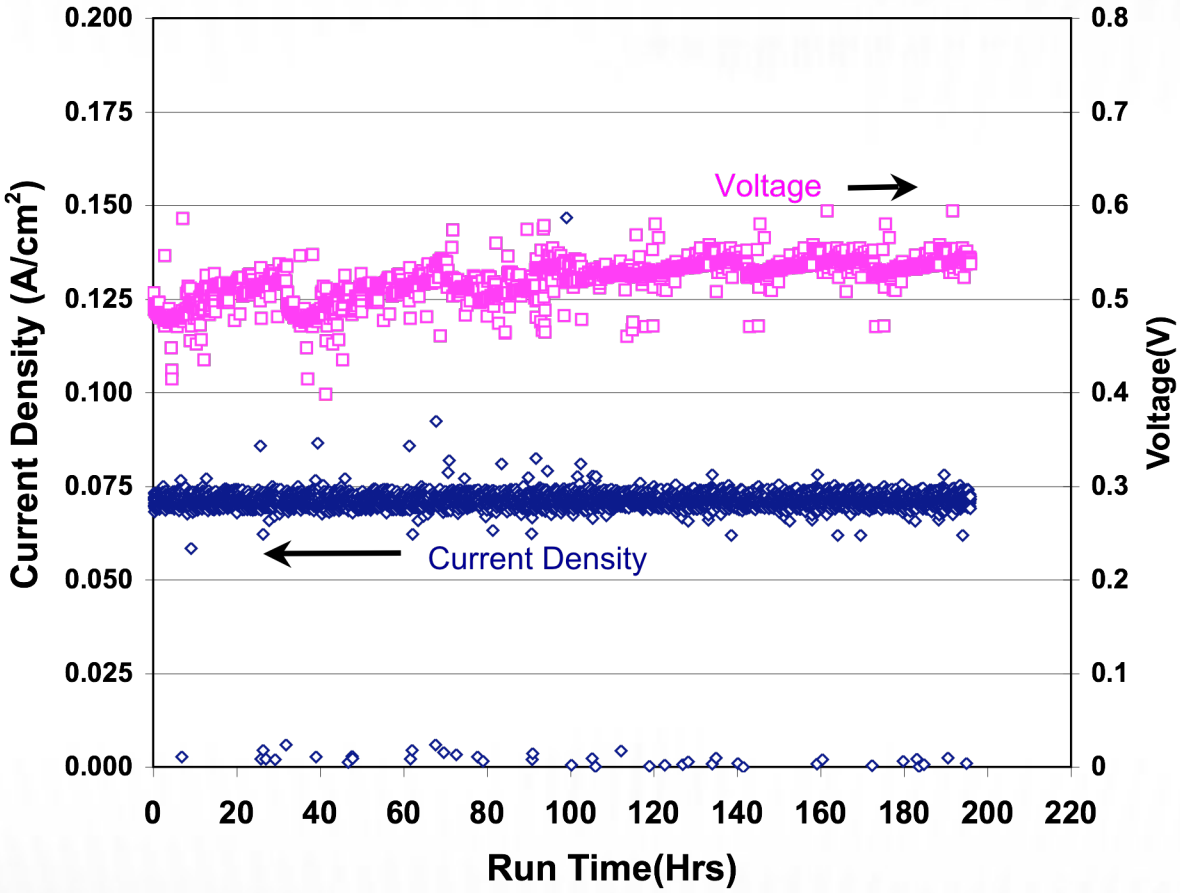


Anode supported P-SOFC





Stability in Syngas



- Fuel: Simulated high utilization (90%CO_2 - balance humidified H_2)

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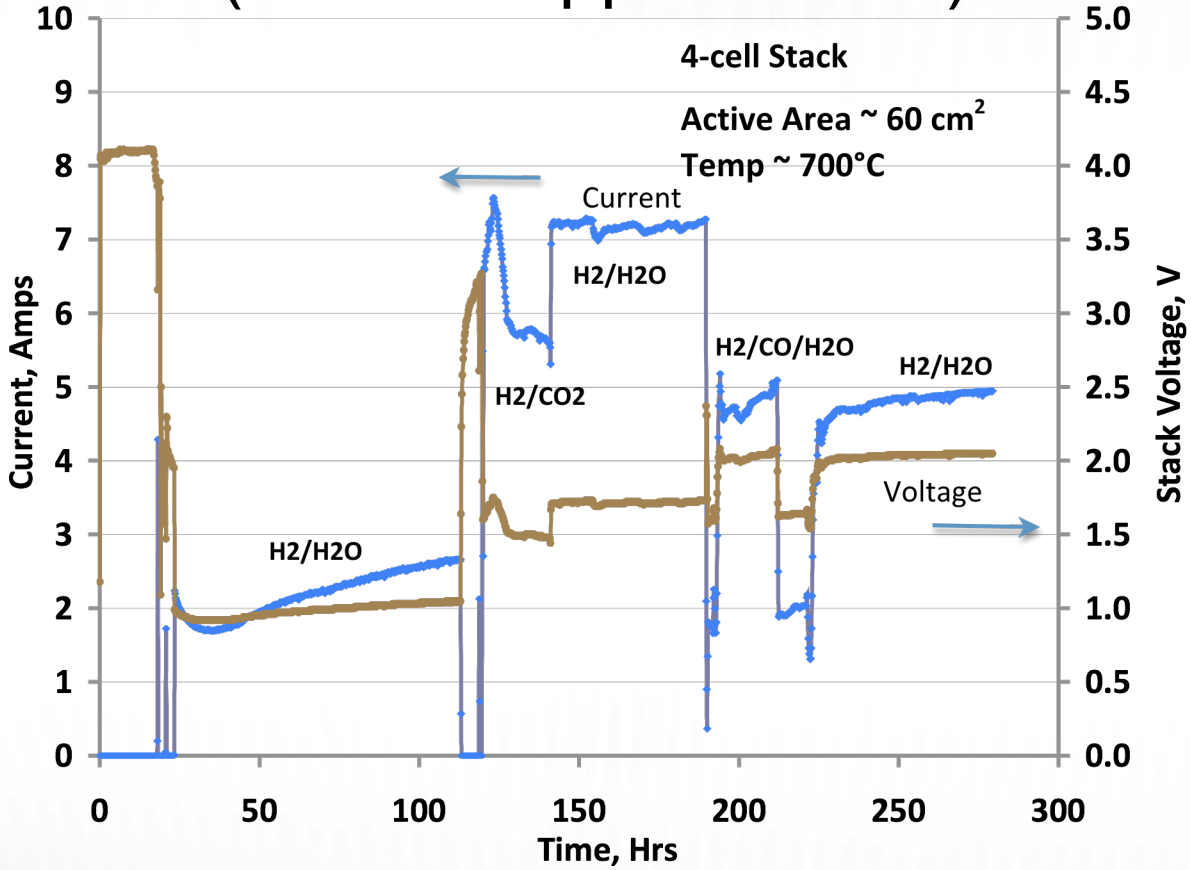
Short Stack Test

(Anode supported cell)



- Good stability demonstrated
- Need to improve cell fabrication process to achieve high performance

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Conclusions

- Proton SOFC shows high efficiency possibility
- Practical compositions requires operating temperatures of 700°C or below to realize high t_H
- Thin, supported electrolyte cells demonstrated
- Chemical stability in syngas can be improved by the composite approach
- Cell fabrication process need to be improved to achieve high quality cells (no pin-holes etc.) for performance equivalent to button cells