Alkali-Free Viscous Sealing Glasses for Solid Oxide Fuel Cells

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DOE SBIR Phase II Contract # DE-SC0002491

Why Consider a Viscous Glass Seal for an SOFC?

- Potential for lower thermal stresses through viscous relaxation at operational temperatures
- Less critical that seal has CTE mismatch to dissimilar materials
- Potential for ‘re-sealing’ at operational temperatures through viscous flow
- Potential solution for the flatness and/or parallelism issue of (planar) cells for large scale SOFCs

Objectives

- Develop glass compositions that exhibit stable thermomechanical/thermochemical properties, including viscosity, for use as seals for SOFCs
  a) Long-term stability in viscosity (650-850°C)
  b) Tg > 650°C: thermal stress will be relieved
  c) Tg > 650°C: requisite flow for re-sealing behavior
  d) Tg > 800°C (as low as possible): a small volume fraction of crystals
  e) CTE(T<sub>g</sub>-sub,T<sub>g</sub>): 10.125-10^{-10}°C

- Conduct hermetic sealing tests
- Characterize thermochemical reactions

Promising Compositions Were Identified

- Preferred compositions exhibit promising sealing behavior

Hermetic Sealing Tests

- Glass 73 seal has survived 100 thermal cycles (750°C to RT; cooling rate ~13°C/min, heating rate ~13°C/hr) in dry air and wet forming gas at a differential pressure of 0.5 psi (28 Torr) over the course of 15,000 hours without failure and the test was deliberately terminated for analysis

Re-Sealing Tests

- Tried to break a seal by fast cooling as possible in the furnace, but no seal failure
- Glass 73-Coupon: No seal failure up to 15 psi, 850°C

Re-Sealing Tests (ex-situ)

- Glass 73-Coupon: Thermally cracked and healed
  Seal originally found to be hermetic
  Glass seal deliberately cracked by high cooling rate quench (~25°C/s)
  Crack healed after re-heating to 725°C for 2 hrs

Long-Term Reactivity Characterization-thermally cycled

- Excellent wetting and bonding to both aluminized metal and YSZ
- Glass is homogeneous
- No crystals in glass
- No significant elements from metal or ceramics diffusing into glass
- BaSi<sub>2</sub>O<sub>5</sub> layer at glass/metal interface

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Volatility of Glasses

- Summary of re-sealing tests (ex-situ)

Crystal Growth Kinetics Depend on Alumina Content

- Summary
  - We have developed an alkali-free Ba-borosilicate glass that resists crystallization under SOFC operational conditions
  - We have produced hermetic seals with SOFC components
    - survive thermal cycling
    - reseal when thermally shocked
  - These glasses can react with aluminized stainless steel and celsian (BaAl<sub>2</sub>Si<sub>2</sub>O<sub>8</sub>) will form under SOFC operational conditions

Acknowledgements

- SECA
- DOE SBIR Phase II Contract # DE-SC0002491
- DOE Project Officer: Dr. Joseph Stoffs, NETL
- Dr. Yeong-Shyung Matt Chou/Dr. Jeff Stevenson, PNNL

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