Glass-Ceramic Seals for Solid Oxide Fuel Cells

Teng Zhang, Signo T. Reis and Richard K. Brow

7th Annual SECA Workshop
September 12-14, 2006
Philadelphia, PA

Materials Science & Engineering Department
University of Missouri-Rolla
Rolla, MO 65409

Goal: Develop stable sealing materials for SOFCs
- ZnO-modified alkaline earth invert silicates
- Mixed CaO, SrO, ZnO (45-55 mole%)
- BaO-free
- (O)\((\text{SrO})_{50-60} \cdot (\text{ZnO})_{50-60} \cdot \text{SiO}_2<45\) mole%

Property design targets:
- Seal/crystallized <900°C
- CTE-match to SOFC components
- Thermomechanically stable at >750°C
- Thermochemically stable in oxidizing and reducing conditions

Certain glasses have good thermal stability
- Using Rietveld refinement

We study the crystal phase distributions using Rietveld refinement

Summary of thermal cycling experiments

<table>
<thead>
<tr>
<th>Sealing materials</th>
<th>Test Condition</th>
<th>Number of Cycles</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 24 hours, air</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 28 hours, air</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 31 hours, air</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 24 hours, wet forming gas</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 28 hours, wet forming gas</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 31 hours, wet forming gas</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 24 hours, He gas</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 28 hours, He gas</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 31 hours, He gas</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 24 hours, air, 10 vol % Ni</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 28 hours, air, 10 vol % Ni</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 31 hours, air, 10 vol % Ni</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 24 hours, He gas, 10 vol % Ni</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 28 hours, He gas, 10 vol % Ni</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
<tr>
<td>MOSci/YSZ</td>
<td>800°C, 31 hours, He gas, 10 vol % Ni</td>
<td>91</td>
<td>Failed, glass prepared at UMR</td>
</tr>
</tbody>
</table>

Current Research Efforts
- Hermetic tests at temperature
- Inconel test manifold under construction
- Scale-up studies of promising compositions
- Kiln melts
- 'Commercial' tape casting/ screen printing
- 100 mm x 100 mm cells
- Interfacial reactions under SOFC conditions
- With ferritic steels and Ni/YSZ anodes
- Glass property optimization
- Viscosity characterization

Acknowledgements
Many colleagues have contributed their expertise and advice to this project, including
- Xiaodong Zhou, Harlan Anderson, Clarissa Vierrerthe, Chandra Ray and Jimbo Yang (UMR)
- Ron Loehman (Sandia National Labs)
- Matt Chou (PNNL)

The financial support of the Department of Energy (grant number DE-FG26-05NT44221) is gratefully acknowledged.

Ayyakkannu Manivannan, Program Manager.