

## Resilient sealing materials for solid oxide fuel cells

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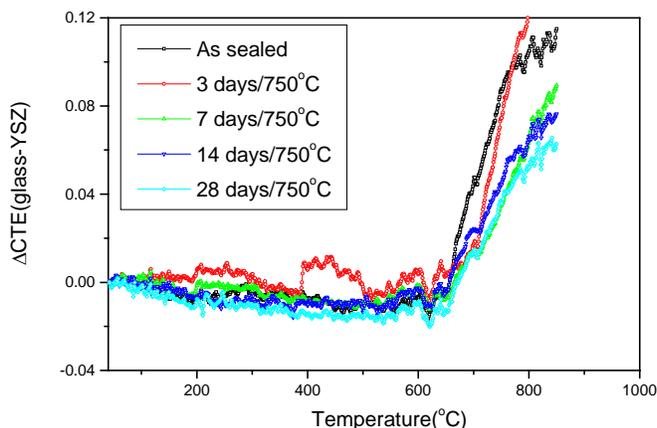
NT42175 (DE-PS26-04NT41898-09)  
Period of performance: Oct. 1, 2004-Sept. 30, 2006

### Objective

The objective of this Phase I program is to develop, characterize, fabricate, and test a hermetic solid oxide fuel cell (SOFC) seal based on a thermochemically-stable glass-ceramic system. The seal will be fabricated below 900°C and will remain stable for prolonged exposures to cell operating environments, including temperatures in the range 750-800°C.

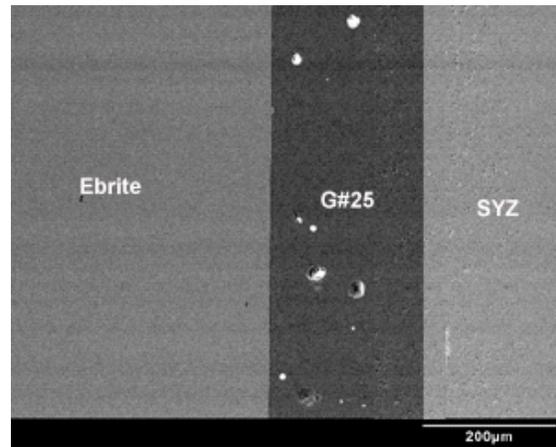
### Accomplishments to Date

We have developed and characterized several glass compositions that appear to possess the chemical and thermal properties desirable for a host matrix for resilient composite sealing materials. The glasses are based on the alkaline earth-zinc-silicate system, with other oxides added to control crystallization behavior and to tailor thermal properties. Certain compositions possess good thermal expansion matches to Y-stabilized zirconia (YSZ), before and after crystallization. For example, the figure to the right shows the expansion difference between a crystallized glass (designated 'glass #27) and YSZ, after heat-treatment at 750°C for up to 28 days. The expansion characteristics of the glass-ceramic do not change significantly below about 600°C.



We have characterized the crystallization kinetics of materials like glass #27 and we have characterized the thermal stability in wet, reducing (5% H<sub>2</sub>/95% N<sub>2</sub>) conditions. These latter experiments provide useful information that guides our compositional development work.

We have developed techniques to bond our glass to materials used in solid oxide fuel cells. For example the figure to the right shows a glass seal, about 200 microns wide, that bonds YSZ to E-brite, a Cr-steel that has been considered for SOFC interconnects. A study of the interfacial reactions between our glasses and the SOFC materials is underway.



The tasks presently underway are summarized below:

1. Characterize processing-dependent properties of the host glasses, including melt viscosity, wetting characteristics to SOFC materials, and crystallization kinetics.
2. Develop processing techniques for making composite seals using glasses like those discussed above with ceramic or metal powders to promote 'controlled fracture' during thermal cycling.
3. Build helium leak-detection system to test the efficacy of the new sealing materials at use temperatures and after thermal cycling.

Publications (since October 1, 2004):

- S.T. Reis, R.K. Brow, "Designing Sealing Glasses for Solid Oxide Fuel Cells," Proceedings of the ASM Materials Solution Conference, Fuel Cells: Materials, Processing and Manufacturing Technologies, Columbus, OH Oct. 18-20, 2004.

Presentations (since October 1, 2004):

- R. K. Brow and S.T. Reis, "Designing Sealing Glasses for Solid Oxide Fuel Cells," ASM Materials Solution Conference, Fuel Cells: Materials, Processing and Manufacturing Technologies, Columbus, OH Oct. 18-20, 2004 (INVITED).
- T. Zhang, S. T. Reis, and R. K. Brow, "Glass-ceramic seals for solid oxide fuel cells," NSF I-U Center for Glass Research, Semi-annual meeting, Sarasota, FL, January 19-21, 2005.
- S. T. Reis\*, R. K. Brow, and P. Jasinski, "Developing Glass Seals for Solid Oxide Fuel Cells," 2<sup>nd</sup> International Symposium on Solid Oxide Fuel Cells: Materials and Technology, 29<sup>th</sup> International Cocoa Beach Conference and Exposition on Advanced Ceramics and Composites, Cocoa Beach, FL, January 23-28, 2005.
- R.K. Brow\*, "Glass Seals for Solid Oxide Fuel Cells," Iowa State Materials Science & Engineering Seminar, Ames, IA, March 3, 2005. (INVITED)
- Teng Zhang\*, S. T. Reis, and R. K. Brow, "Glass Seals for Solid Oxide Fuel Cells," 107<sup>th</sup> Annual Meeting of the American Ceramic Society, Baltimore, MD, April 10-13, 2005.
- R.K. Brow, "Thermochemically stable sealing materials for solid oxide fuel cells," Solid State Energy Conversion Alliance 6<sup>th</sup> Annual Workshop, Pacific Grove, CA, Apr. 18-21, 2005. (INVITED)
- R.K. Brow, "Sealing Glasses for Solid Oxide Fuel Cells," 17<sup>th</sup> University Conference on Glass Science and 1<sup>st</sup> International Materials Institute Workshop on "New Functionality in Glasses", Penn Stater Conference Center Hotel, State College, PA, June 26-30, 2005. (INVITED)