Silicate Glass Composite Seals for SOFCs

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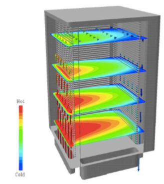
Background

Crystallization-resistant glasses are being considered for SOFC sealing applications because of their self-healing characteristics and ability to relax thermal stresses *via* viscous flow. Furthermore, their chemical composition and physical and mechanical properties can be tailored to match SOFC designs requirements.

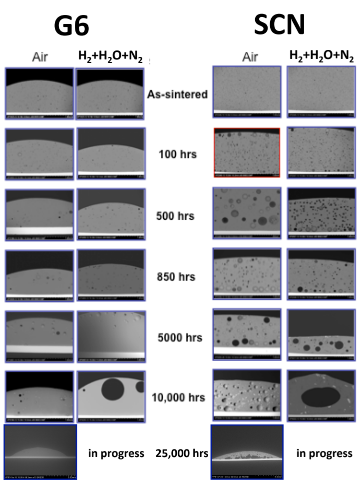
Here we present results from the characterization of Engineered Glass Seals, consisting of a crystallization-resistant glass matrix and a ceramic frangible, compliant second phase.

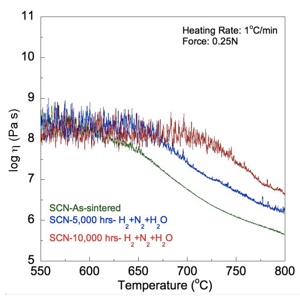


Large in-plane and axial temperature gradients exist in SOFC stacks during operation.

Composite seals can be designed to exhibit a range of viscosity values to perform over the large temperature gradients experienced by SOFCs and with necessary compliance to accommodate stack displacements, particularly for cells with large active surface area, which might not be flat or parallel.

Characterization of multicomponent silicate glasses





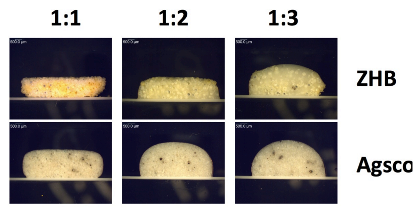
Effect of time of exposure on the viscosity of SCN glass (top) and microstructural evolution of SCN and G6 glasses sintered onto YSZ substrates (left).

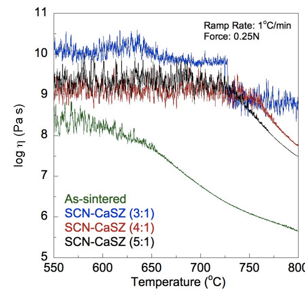
The effect of time of exposure (in air or in a gas mixture of $H_2+N_2+H_2O$) on the microstructure and chemical composition of two multicomponent silicate glasses (SCN and G6) is being investigated for times of exposure in excess of 25,000 hrs.

The kinetics of precipitation of crystalline phases (e.g., BaO, $KAlSi_3O_8$, $MgCaSi_2O_6$, $CaSiO_3$) have been determined, along with the evolution of the distribution of pore sizes.

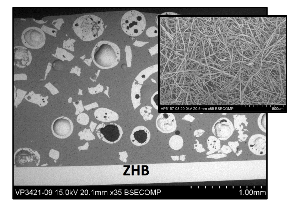
SCN: SEM-COM Co. Inc., Toledo, OH 43623.
G6: Whatman, Piscataway, NJ 08855

Engineered composite seals





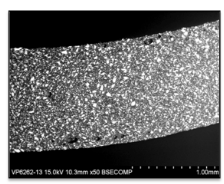
Viscosity of composite seals as a function of temperature and concentration of second phase (top) and scanning electron micrograph (bottom).



Engineered seals consisting of a multi-component silicate glass matrix and zirconia-based frangible particles or ceramic fibers have been developed.

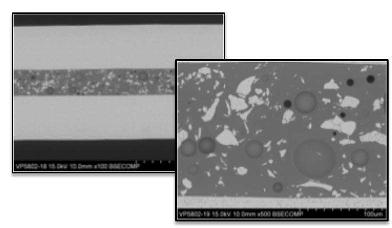
Their wetting behavior and thermophysical properties have been characterized as a function of temperature and concentration of second phase.

Mixtures of SCN or G6 glasses, frangible zirconium oxide particles or fibers and an organic binder (polylactide acid) have been blended to achieve homogeneous and uniform compositions, which can be subsequently extruded and deposited by fused deposition.



Extruded filament consisting of polyactide acid, SCN glass and frangible ceramic particles for fused deposition

Engineered glass seals have also been successfully manufactured by tape casting and screen printing. The figure on the right shows a screen-printed seal consisting of G6 glass and frangible YSZ particles between two 8YSZ tapes.



Summary

Engineered composite seals, consisting of a multicomponent silicate glass matrix and zirconia-based second phase (frangible particles or fibers) have been developed for SOFCs. Their physical properties (e.g., compliance, viscosity, thermal expansion) can be tailored to address the wide distribution of temperatures experienced by SOFCs and to seal cells with large active surface area, which might not be parallel or flat. The effect of time of exposure (in air or in a gas mixture of $H_2+N_2+H_2O$) on the microstructure and chemical composition of two multicomponent silicate glasses has been studied for times of exposure in excess of 25,000 hrs. Low-cost manufacturing procedures are being developed, including fused deposition, which provides a means for printing seals with a spatial distribution of viscosity values and high material utilization.

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