

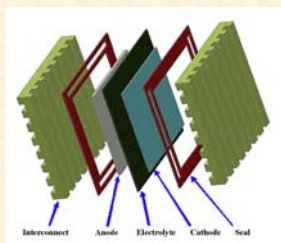
Characterization of glasses for SOFC sealing applications

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OBJECTIVE: To characterize the phase stability and chemical compatibility of candidate glass seal materials

SOFC glass seals

- Requirements for SOFC Seals
- Simultaneous fulfillment of thermal, physical, chemical, mechanical and electrical property requirements.
- Phase stability and chemical compatibility without substantial property degradation for 40,000 hours in oxidizing and wet reducing environments.



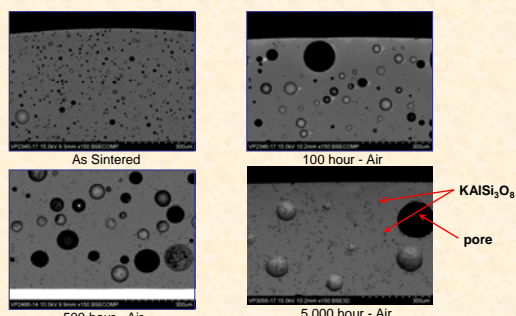
*Mahapatra and Lu, *J Power Sources*, 2010

SCN – An Alkali Barium Silicate glass

- Manufactured by SEM-COM, Toledo, OH
- Glass received in powder form. Powder cold pressed into pellets and then sintered at 850°C for 2 hours. Specimens exposed at 800°C for 5,000 hours on 8YSZ and Alumina substrates* (longer term exposures in progress)
- Exposure in air and steam+H₂+N₂ environments

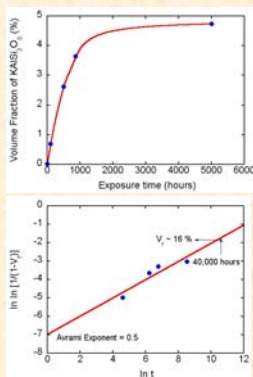
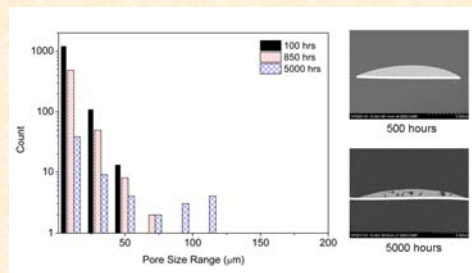
Ingredient	Concentration
SiO ₂	<75%
K ₂ O	<12%
BaO	<10%
Na ₂ O	<8%
Al ₂ O ₃	<5%
TiO ₂	<1%
Ce ₂ O ₃	<1%
As ₂ O ₃	<1%
Sb ₂ O ₃	<1%
MgO	<2%
CaO	<5%
F ₂	<1%

Microstructural Evolution



- Pores coarsen; volume fraction of KAlSi₃O₈ precipitates increases

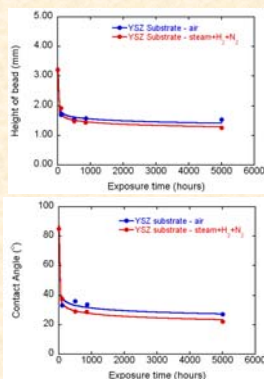
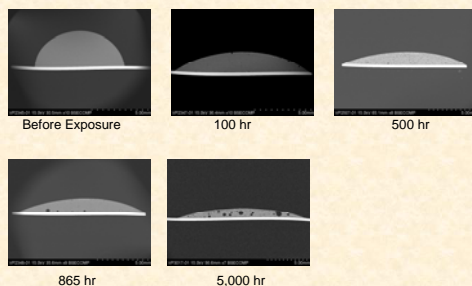
Substrate: 8YSZ; environment: steam+H₂+N₂



- Fewer but larger pores at longer times of exposure
- Heterogeneous microstructure
- At present rate ~15% of glass would crystallize after 40,000 hours

Effect of time of exposure on dimensional stability

Substrate: 8YSZ; environment: steam+H₂+N₂



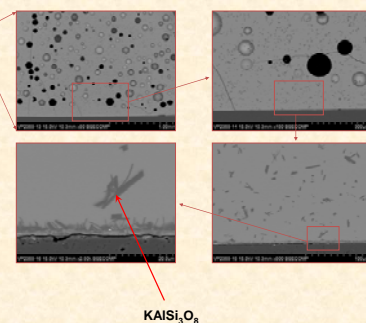
- SCN glass flows more easily in the steam-rich environment as a result of differences in surface tension compared to air

Phase stability of SCN - Alumina substrate

After 865-Hour Exposure in Air

Exposure Condition	Glass	KAlSi ₃ O ₈	BaO	Ca-rich silicate	SiO ₂	Bead Attached
SCN Glass - As sintered	✓	x	x	x	x	x
100 hours - Air	✓	✓	x	x	x	x
100 hours - Steam+H ₂ +N ₂	✓	✓	✓(s)	x	x	x
500 hours - Air	✓	✓	x	x	x	x
500 hours - Steam+H ₂ +N ₂	✓	✓	✓(s)	x	x	x
865 hours - Air	✓	✓	✓(s)	x	x	✓(r)
865 hours - Steam+H ₂ +N ₂	✓	✓	✓(s)	✓(s)	x	x
5000 hours - Air	✓	✓	✓(s)	✓(s)	x	✓(r)
5000 hours - Steam+H ₂ +N ₂	✓	✓	✓(s)	✓(s)	x	✓(r)

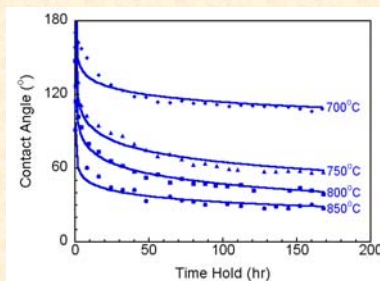
✓(s) - Phase forms only on the surface of the bead
✓(r) - Bead remains attached due to formation of reaction layer



In situ Wetting Behavior Measurements

8YSZ Substrate

800°C exposure images



- Wetting behavior as a function of temperature, time and substrates
- SCN glass wets both substrates at temperatures > 750°C.

Summary

- The effect of time of exposure in air and steam+H₂+N₂ at 800°C on the properties and the microstructural, chemical and dimensional stability of SCN glass was investigated
- The kinetics of devitrification and pore size evolution were characterized and preliminary estimates for the concentration of pores and crystalline phases have been obtained for 40,000 hrs.
- Long-term exposure of SCN glass (20,000 hours+) is in progress.

Acknowledgements

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