Durability and Reliability of Materials and Components for Solid-Oxide Fuel Cells

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Acknowledgments

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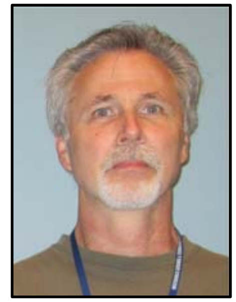

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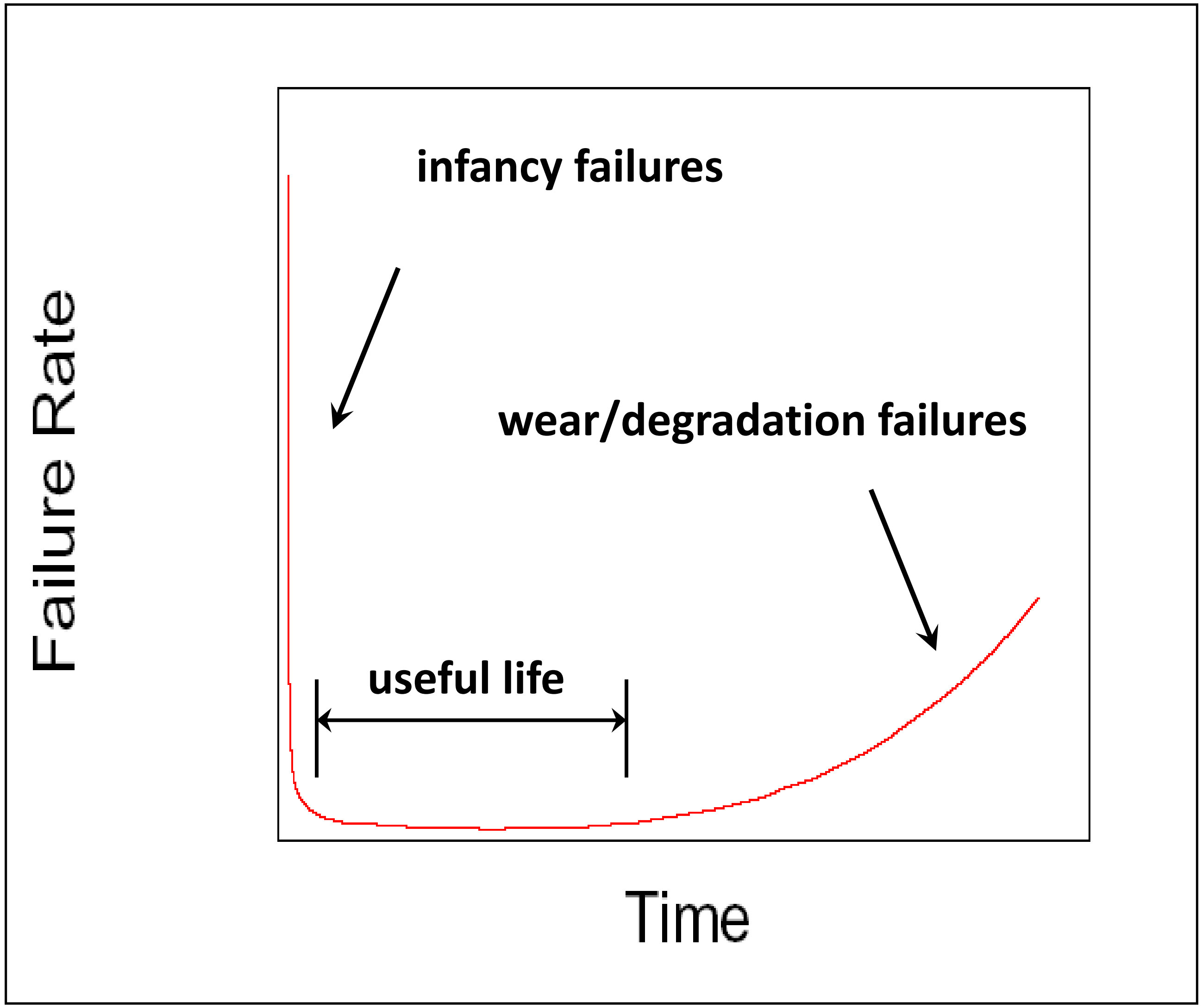
Background

- Background
- Project Objectives
- Microstructural evolution of glass seals, 8YSZ and Al_2O_3
- Redistribution of stresses during creep
- Future work

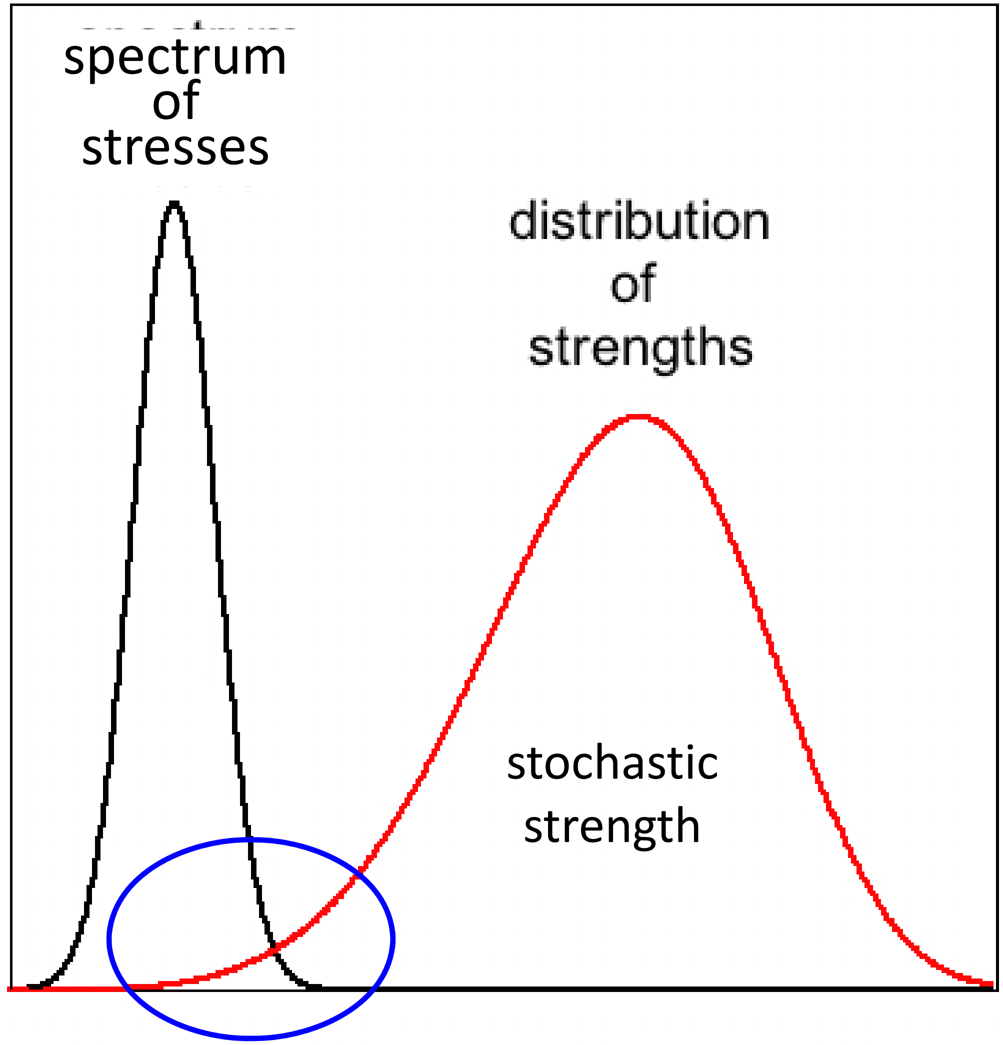
Failure, Reliability and Durability of Systems

The failure rate of complex systems can be described by the bathtub curve

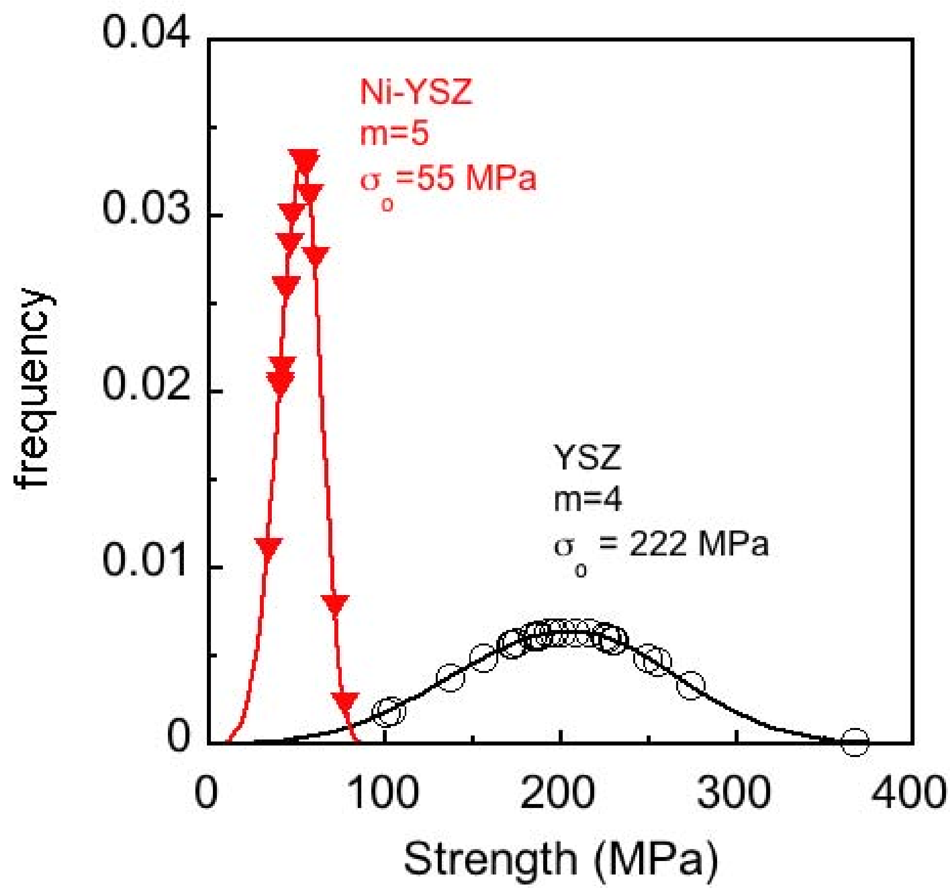


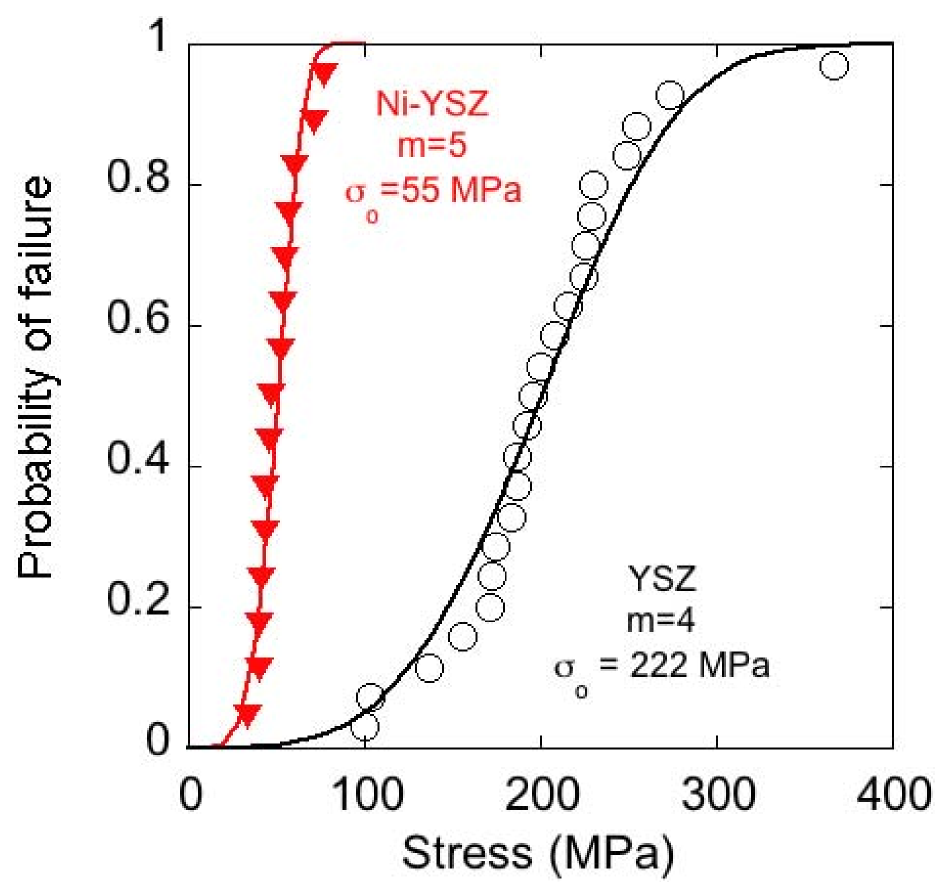
Failure, Reliability and Durability of Systems

- Failure is determined by the intersection of the distributions of loads and strengths.
- The weakest elements of the population determine the reliability of the system.



Strength of SOFC Materials





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Objectives

- To understand the effect of time and temperature on the microstructural evolution of materials and components for solid-oxide fuel cells
- To understand the effect of creep deformation of anode materials on its microstructure and on the redistribution of stresses in solid-oxide fuel cells

Engineered Composite Glass Seals

US009564643B2

(12) **United States Patent**
Surdoval et al.

(10) **Patent No.:** **US 9,564,643 B2**
(45) **Date of Patent:** **Feb. 7, 2017**

(54) **ENGINEERED GLASS SEALS FOR SOLID-OXIDE FUEL CELLS**

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(65) **Prior Publication Data**

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(51) **Int. Cl.**

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H01M 8/02	(2016.01)
C03C 8/24	(2006.01)
C03C 14/00	(2006.01)
H01M 8/12	(2016.01)

(52) **U.S. Cl.**

CPC ***H01M 8/0282*** (2013.01); ***C03C 8/24*** (2013.01); ***C03C 14/002*** (2013.01); ***C03C 14/004*** (2013.01); ***H01M 8/0286*** (2013.01); *C03C 2214/30* (2013.01); *H01M 2008/1293* (2013.01); *Y02E 60/50* (2013.01); *Y02E 60/525* (2013.01); *Y02P 70/56* (2015.11)

(58) **Field of Classification Search**

CPC H01M 8/0282; H01M 8/0286; H01M 2008/1293; C03C 8/24; C03C 14/002; C03C 14/004; C03C 2214/30; Y02E 60/525; Y02E 60/50; Y02P 70/56

USPC 429/509

See application file for complete search history.

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(Continued)

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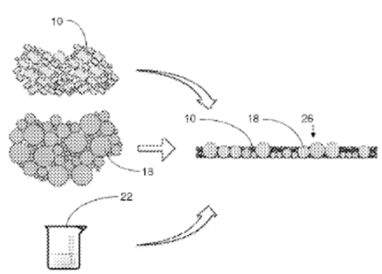
(57) **ABSTRACT**

A seal for a solid oxide fuel cell includes a glass matrix having glass percolation therethrough and having a glass transition temperature below 650° C. A deformable second phase material is dispersed in the glass matrix. The second phase material can be a compliant material. The second phase material can be a crushable material. A solid oxide fuel cell, a precursor for forming a seal for a solid oxide fuel cell, and a method of making a seal for a solid oxide fuel cell are also disclosed.

19 Claims, 7 Drawing Sheets



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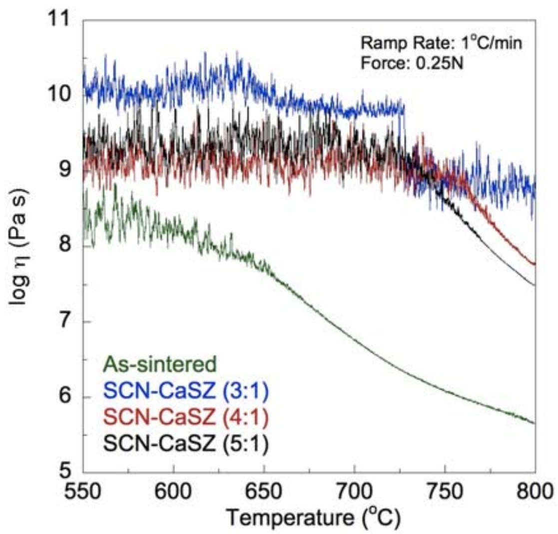
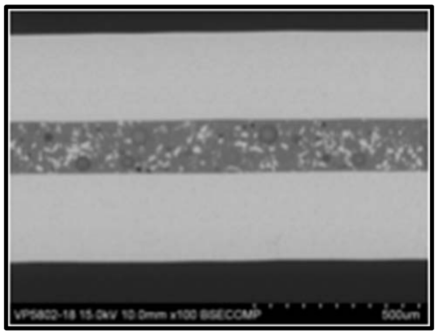
Engineered Composite Glass Seals

Engineered composite seals, consisting of a multicomponent silicate glass matrix and a zirconia-based second phase (frangible particles or fibers), have been developed for Solid Oxide Fuel Cells (SOFCs) and other high-temperature sealing applications. The physical properties (e.g., compliance, viscosity, thermal expansion) of the seals can be tailored to address, for example, the wide distribution of temperatures experienced by SOFCs and to seal cells with large active surface area, which might not be parallel or flat.

Low-cost manufacturing procedures have been developed, including fused deposition, which provides a means for printing seals of complex shape with an arbitrary spatial distribution of viscosity values and high material utilization.

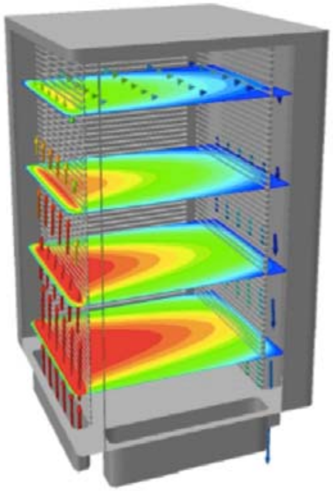


Viscosity of engineered glass seals as a function of temperature and volume concentration of second phase (zirconium oxide particles).



Scanning electron micrograph illustrating the cross section of an engineered glass seal between two aluminum oxide plates. The zirconia particles embedded in the glass are evident in the micrograph.

Picture of engineered glass seal fabricated by fused deposition using a mixture of glass and ceramic particles embedded in an organic binder.



The viscosity of engineered composite seals can be tailored to seal structures, such as SOFCs, that experience large in-plane and axial temperature gradients during operation.

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