

# **SOFC Seals: Requirements, Issues, Advanced Concepts**

**SECA Core Technology Program – SOFC Seal Meeting**

**July 8, 2003**

**Sandia National Laboratory, Albuquerque, NM**

# SOFC SEALS

## Functions

- SOFC seals prevent mixing of fuel and oxidant within stack
- SOFC seals prevent leaking of fuel and oxidant from stack
- SOFC seals electrically isolate cells in stack
- SOFC seals may provide mechanical bonding of components

## Requirements

**While fulfilling the above functions, seal materials must remain:**

- structurally stable**
- chemically compatible with other stack components**
- inexpensive**

# Recap: SOFC Seal Requirements

## Functional requirements and materials selection parameters

<b>Mechanical</b>	<ul style="list-style-type: none"><li>• Hermetic (or near hermetic)</li><li>• Minimal CTE mismatch (or ability to yield or deform to mitigate CTE mismatch stresses)</li><li>• Acceptable bonding strength (or deformation under compressive loading)</li><li>• Thermal cycle stability</li><li>• Vibration and shock resistance (for mobile applications)</li></ul>
<b>Chemical</b>	<ul style="list-style-type: none"><li>• Long-term chemical stability under simultaneous oxidizing/wet fuel environments</li><li>• Long-term chemical compatibility with respect to the adjacent sealing surface materials</li><li>• Resistance to hydrogen embrittlement/corrosion</li></ul>
<b>Electrical</b>	<ul style="list-style-type: none"><li>• Non-conductive</li></ul>
<b>Fabrication</b>	<ul style="list-style-type: none"><li>• Low cost</li><li>• High reliability with respect to forming a hermetic seal</li><li>• Sealing conditions compatible with other stack components</li></ul>

# Recap: SOFC Seal Materials “Issues”

- Long term structural stability
  - Bulk cracking
  - Re-crystallization
  - Interface de-bonding
  - Reaction products: Layer formation, Porosity formation
- Chemical stability
  - Interface reactions
  - Evaporation
  - Dissolution
  - Hydrogen-assisted corrosion

# ***SOFC SEALS: Food for Thought***

## **Fundamental Room Temperature Analogs:**

**Rigid Glue (Epoxy)**

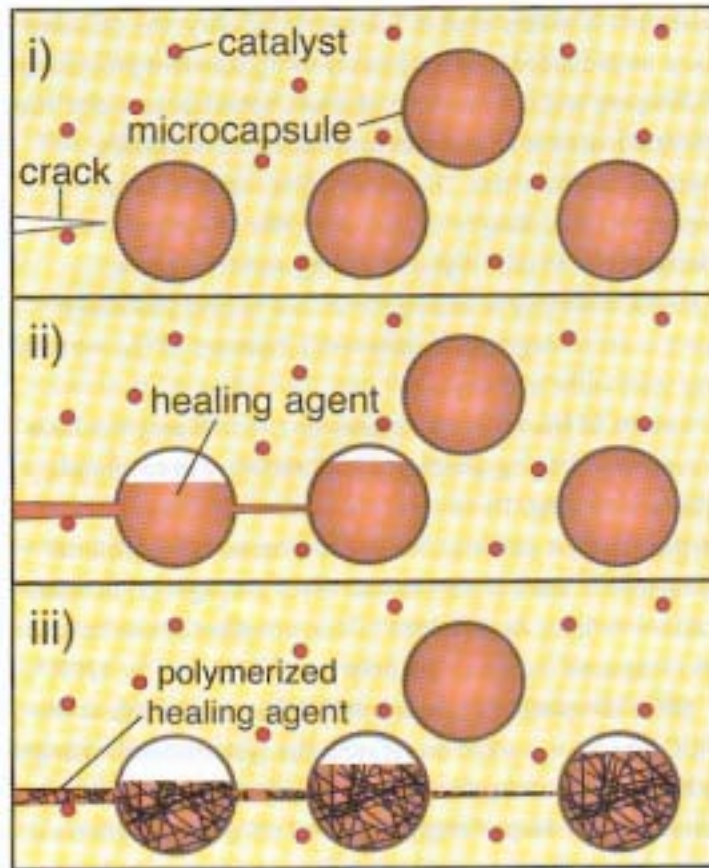
**Compliant Glue (Rubber cement)**

**Compressive Seal (Rubber O-rings, head gasket)**

## **Advanced Seal Concepts:**

- **Self healing ceramic composite seals**
- **Graded TEC seals**
- **Wet seals**
- **High temperature spring seals**

# Self-healing Seals



Room temperature analog:

## Self-healing Polymers

Might improve toughness of glass-ceramic seals, but keep in mind that glass seals frequently fail at interfaces rather than through bulk

Gould, "Self-help for ailing structures," *Materials Today*, p. 44, June 2003

Bulk healing triggered by changes in temperature or environment ?

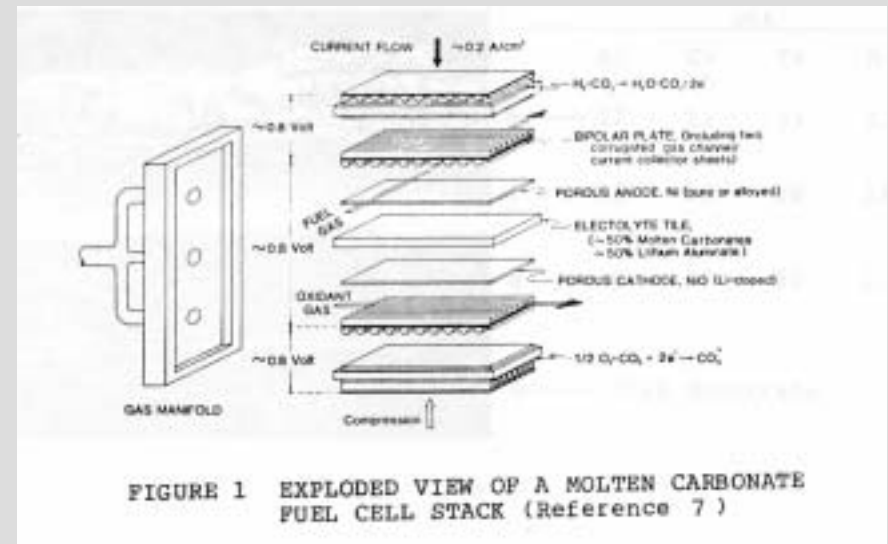
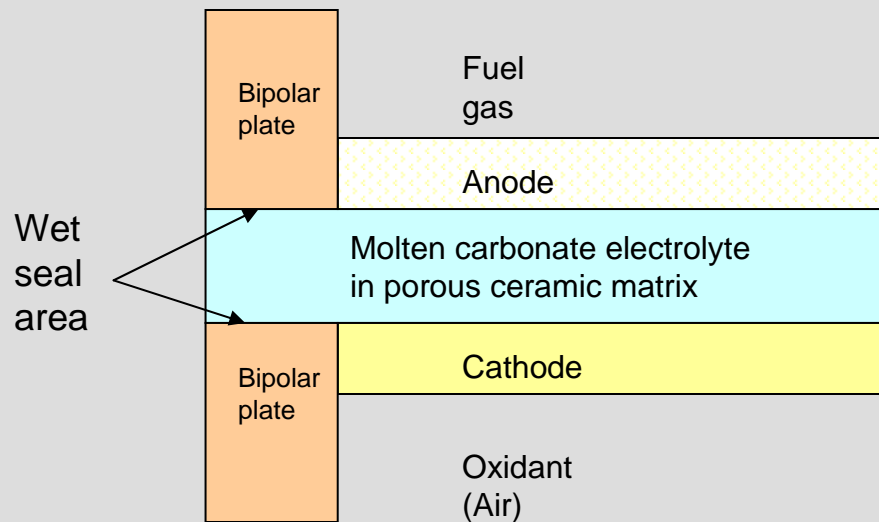
# Graded CTE Seals



**Is CTE grading possible in thin sections?**

# Wet Seals

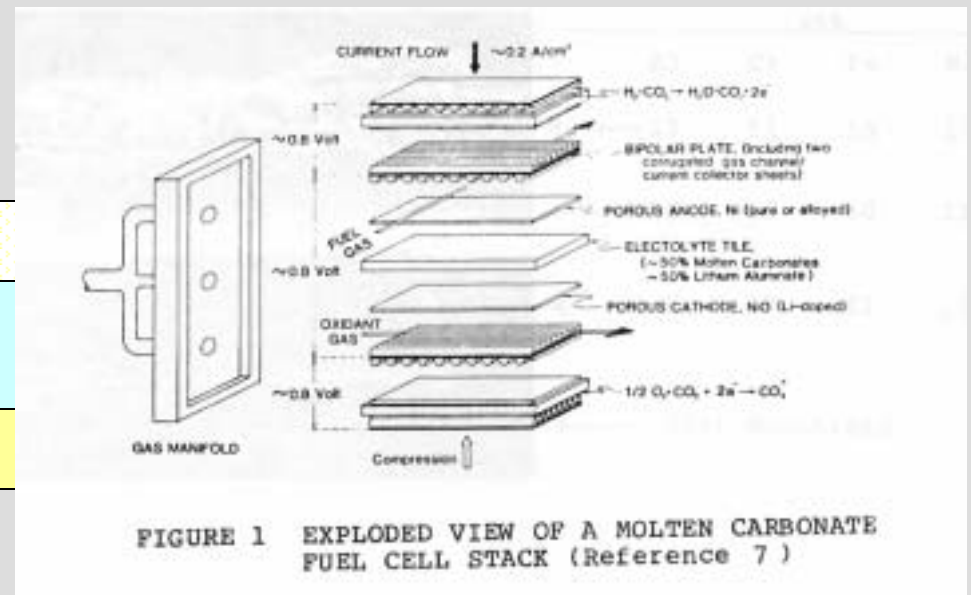
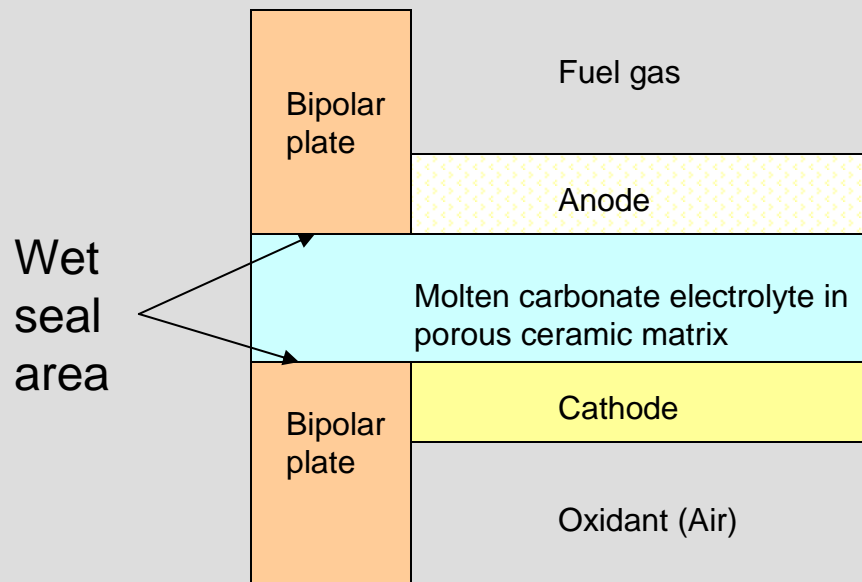
- ▶ At operating temperature, seal is liquid (highly viscous or contained in porous matrix by surface tension).
- ▶ At low temperatures, seal solidifies, but is non-bonding, allowing for sliding to prevent stress buildup
- ▶ Utilized in Molten Carbonate Fuel Cells (600-700°C)
  - Singh et al., Corrosion 87, NACE (1987).





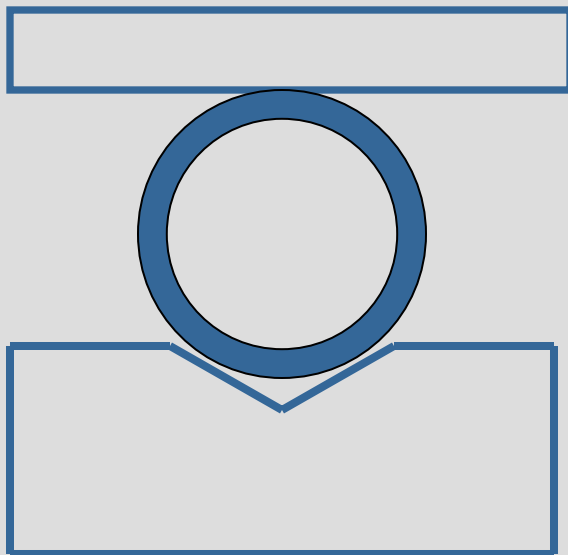
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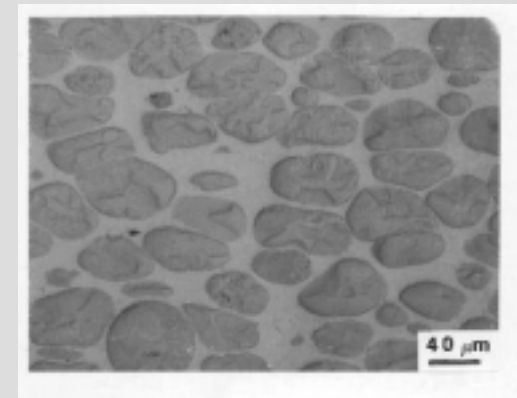


# Compliant Metal Spring Seals

- ▶ High temperature “springs”
  - E.g., Metal O-rings in a groove
  - Fill hollow tube with ceramic fiber?
  - Ceramic coating to provide electrical insulation?



Controlled  
thermal  
expansion  
metal  
matrix  
composites



**High Spring back / Electrical insulation ?**