Mechanical Evaluation of Materials and Components for SOFCs

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Outline

- Objectives
- Approach
- Examples
- Summary
Objectives

• To use standardized and customized test methods for the generation of mechanical and performance data of SOFC materials and components in support of the modeling efforts (Core Technology Program).

• To support the Vertical Teams in establishing structure-property relationships for SOFC materials and components.
Approach

- Elastic constants as a function of temperature
- Fracture toughness
- Uniaxial and biaxial monotonic strength
- Thermal shock
- Thermal and mechanical fatigue
- Creep
- Chemical strains (compositional gradients)
- Interfacial toughness in multilayered structures
- Other
Standard test methods

C 1161 Flexure Strength (Room Temp.)
C 1211 Flexure Strength (High Temp.)
C 1323 C Ring Strength
C 1273 Tension Strength, Room Temp.
C 1291 Creep, Creep Rupture
C 1322 Fractography
C 1326 Knoop Hardness
C 1327 Vickers Hardness

Elastic Moduli
C 1198 Continuous Excitation
C 1259 Impulse Excitation

NDE and Design
C 1212 NDE Seeded Voids
C 1336 NDE Seeded Inclusions
C 1331 Ultrasonic Velocity
C 1332 Ultrasonic Attenuation
C 1239 Weibull Analysis
C 1175 NDE Guide

Classification
C 1286 Classification
Elastic Properties
Elastic Properties

Biaxial Strength
Biaxial Strength

Weibull plot of biaxial flexural strength of tape-cast YSZ

<table>
<thead>
<tr>
<th></th>
<th>25°C</th>
<th>900°C</th>
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<tbody>
<tr>
<td>$\sigma_{avg}$</td>
<td>416 ± 70 MPa</td>
<td>265 ± 39 MPa</td>
</tr>
<tr>
<td>$\sigma_0$</td>
<td>446 MPa</td>
<td>282 MPa</td>
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<tr>
<td>m</td>
<td>6.7</td>
<td>8.0</td>
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Fractography

Fracture Toughness

Indentation fracture toughness as function of strontium content, x, in La$_{1-x}$Sr$_x$Co$_{0.2}$Fe$_{0.8}$O$_3$.

Y.-S. Chou, J. W. Stevenson, T. R. Armstrong, and L. R. Pederson,
*J. Amer. Ceram. Soc.*, 83, No. 6, June 2000
Fracture Toughness (cont.)

Double-torsion test
Fracture Toughness (cont.)
Fracture Toughness (cont.)

Stress intensity for crack extension of YSZ at constant-displacement rate

![Graph showing stress intensity factor (K) vs. displacement rate (mm/minute). The graph indicates that at 25°C, the stress intensity factor is 1.61 MPa m$^{1/2}$, and at 900°C, it is 1.02 MPa m$^{1/2}$. The graph also shows a linear relationship between stress intensity and displacement rate.]

Properties of Structures

Properties of Structures

Properties of Structures
Thermal Shock

Approach

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Summary

• **Supporting role in modeling effort.**

• **Standardized and customized test methods to evaluate properties and performance.**

• **Identify structure-property/performance relations.**

• **Support vertical teams in material/component development characterization.**
Relationship between bending strength and electric conductivity at 1000°C for ScO-doped zirconia polycrystals (a) sintered at 1300°C, (b) HIPed at 1300°C, and (c) HIPed at 1450°C
Fracture toughness of ScO-doped zirconia polycrystals sintered at 1400°C [18], and HIPed at 1300° and 1450°C versus ScO content.

Bending strength of ScO-doped zirconia polycrystals sintered at 1400°C [18], and HIPed at 1300° and 1450°C versus ScO content.