not only for long-term operation, but also for repeated thermal cycling. In this presentation, we'll give a comprehensive study of two approaches: hybrid mica-based compressive seals and "refractory" sealing glasses. In the compressive mica seal approach, the origin of the primary leak path was examined. The effect of compressive stress and mica thickness were studied. Leak rates during long-term thermal cycling and long-term isothermal aging were evaluated. Materials degradation will be discussed. The refractory glass seal approach also be explained. Glass Compositions will be discussed in terms of thermal properties. Results for sealed coupons will be reported. Thermodynamic calculations of interfacial reactions will be compared with experimental results. Finally, leak test results for large samples will be reported to provide a more complete assessment of the seal.

10:10 AM
Effects of Atmospheres on Bonding Characteristics between Silver and Alumina: *Jin Yong Kim*[1]; Jung Choi[1]; John Hardy[1]; K. Weil[1]; [1]Pacific Northwest National Laboratory

Recently, silver-based reactive air brazing (RAB) has been developed as an effective alternative sealing technique for high temperature electrochemical devices such as solid oxide fuel cells. It was reported that bend strength of brazed joints significantly decreases after thermal aging in hydrogen at high temperature, while the air-treated samples exhibit no degradation in comparion with the as-brazed joints. In this study, the effects of atmospheres on the microstructure, mechanical properties, and bonding characteristics between silver and alumina have been investigated. The detailed results to date will be discussed.

10:35 AM Break

10:50 AM
Stress Induced Disruption of SOFC Interfaces: *Yves Idzerda*[1]; Alex Lussier[1]; Joe Dvorak[1]; Shane Stadler[2]; Johnathon Holroyd[1]; Marco Liberati[1]; Elke Arenholz[3]; Satish Ogale[4]; T. Wu[4]; T. Venkatesan[4]; [1]Montana State University; [2]Southern Illinois University; [3]The Advanced Light Source; [4]University of Maryland

Interfacial stress is thought to have significant effects on electrical and oxygen transport properties of thin films of importance in solid oxygen fuel cell applications. In this work we investigate by X-ray absorption spectroscopy (XAS) and X-ray resonant scattering (XRS) how in-plane biaxial stress modifies the electronic and chemical structure of LaCaMnO (LCM), LaSrMnO (LSM), LaSrCoO (LSC), and LaSrFeO (LSF) thin films. The in-plane interfacial stress was controlled by deposition of these films on different lattice mismatched substrates or deposition of an overlayer material. The transition metal L-edge XAS and XRS data show that the strain response is to modify the interfacial composition of the SOFC film to achieve a better lattice match to the overlayer material, creating an interfacial region that is a severe barrier to oxygen and electron transport. This interface modification due to interfacial stress appears ubiquitous in multi-element systems that also exhibit multi-valency.

11:15 AM
Parametric Investigation of a New Planar Solid Oxide Fuel Cell Sealing Approach Using Finite Element Analysis: *K. Scott Weil*[1]; Brian Koeppel[1]; [1]Pacific Northwest National Laboratory

One of the critical issues in designing and fabricating a high performance planar solid oxide fuel cell (pSOFC) stack is the development of the appropriate materials and techniques for hermetically sealing the metal and ceramic components. We are currently developing a foil-based approach that appears to offer good hermeticity and mechanical integrity, while minimizing the generation of interfacial stresses in either of the joint substrate materials, particulary the ceramic cell. Prior experimental work conducted on small-scale samples demonstrated the viability of the concept. Here we present recent results from computational analyses undertaken to investigate potential issues associated with scaling up the seal to full-scale pSOFC stack dimensions/geometry.

11:40 AM
Shape Memory Alloy/Glass Composite Gas Seal for Solid Oxide Fuel Cells: *Christopher Story*[1]; W. Reynolds[1]; Kathy Lu[1]; [1]Virginia Polytechnic Institute and State University

Widespread use of solid oxide fuel cells is hindered by a lack of long-term durability of seals between metallic and ceramic components. A large mismatch between the thermal expansion coefficients of these components cause the seal between them to crack during thermal cycling. A novel gas seal is being developed which integrates 3D-printed TiNiHf shape memory alloy wires into a SrO-La203-Al203-B2O3-SiO2 glass matrix. The shape memory alloy wires create a thermal expansion gradient in the composite seal, and are also expected to heal cracks in the glass and provide transformation toughening. The seal production method and seal testing will be discussed in this presentation. The TiNiHf alloy has been produced by arc-melting and homogenization, followed by milling to a fine powder and 3D printing. The glass, after homogenization, has been sintered around the TiNiHf wire structure. The behavior of the composite seal during thermal cycling tests will be presented.

12:05 PM
Microstructure and Mechanical Properties of Ceramic Joints Brazed with Copper-Doped Ag-Al Based Braze Fillers: *Jin Yong Kim*[1]; Jung Choi[1]; John Hardy[1]; K. Weil[1]; [1]Pacific Northwest National Laboratory

Silver-aluminum based air braze has been investigated as an alternative braze sealing for high termperature devices. Addition of aluminum was designed to improve the dual atmosphere tolerance of silver based air braze. In the silver based braze filler, it has been reported that addition of copper (oxide) improves the wettability of molten silver on both ceramics and metals, resulting in improved bend strength of their joints. In this study, we attempted to add copper into various compositions of silver-aluminum based braze fillers. We will discuss the effects of copper addition on the microstructure and mechanical strength of brazed ceramic joints.

Materials Processing and Manufacturing Division Symposium: Mechanics and Materials Modeling and Materials Design Methodologies, in the Honor of Dr. Craig Hartley's 40 Years of Contributions to the Field of Mechanics and Materials Science: Homogenization/Constitutive Behavior II

Sponsored by: The Minerals, Metals and Materials Society, TMS Materials Processing and Manufacturing Division, TMS: Shaping and Forming Committee, TMS/ASM: Mechanical Behavior of Materials Committee
Program Organizers: Brent Adams, Brigham Young University; Hamid Garmestani, Georgia Institute of Technology

Tuesday AM — Room: Northern A1
February 27, 2007 — Location: Dolphin Hotel

Session Chairs: Robert Wagoner, Ohio State University; Charles Neu, Forensic Sciences Inc

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9:00 AM
Control of Properties in Deformation Processes Using Multi-Scale Sensitivity Analysis: *Nicholas Zabaras*[1]; Veera Sundararaghavan[1]; [1]Cornell University

Material property evolution during processing is governed by the evolution of underlying microstructural features. We discuss an efficient multi-scale FEM analysis for tailoring properties in forming processes involving polycrystalline materials through control of texture evolution. The multi-length scale deformation process simulator allows for crystal elasto-viscoplasticity and simulation of texturing using continuum representations of the orientation distribution function. Sensitivity of microstructure field variables such as slip resistances and texture due to perturbations in forming parameters such as forging rates, die and preform shapes are exactly defined using multi-scale sensitivity analysis. An averaging principle is developed to compute sensitivity of stress and various material properties at the macroscopic level from microstructural sensitivity fields. These sensitivities are used within a gradient-based optimization framework for computational design of metal forming processes. Examples that illustrate efficiency of this approach in controlling yield strength distribution in the final product during complex 3D deformation processes are shown.