

Thermomechanical Behavior of SOFC Materials

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Many energy systems such as SOFCs and TBCs are processed from, and composed of, layered ceramic components supported on a rigid substrate. These systems are processed at and/or operate at a range of thermal cycles and transients. The reliability and costs of the energy system depends on the ability to predict what conditions lead to failure-causing stresses that arise during operation and processing. Materials can range from completely elastic (E) at room temperature to viscous (η) (i.e., exhibiting time and stress dependent deformation) at high temperature. The intermediate viscoelastic behavior is typical of polycrystalline ceramics and depends on the material, porosity and grain size. By measuring the viscoelastic properties (E , η) of the individual components as a function of temperature we can model the stress states in the energy system during processing and operation. With this knowledge we can understand how to adjust materials, processing and operation conditions to avoid failure.

We have developed testing techniques, such as cyclic loading dilatometry (CLD) and creep beam bending (CBB), to measure the thermomechanical properties of individual ceramic components as a function of relative density and microstructure (i.e. porosity and grain size) up to typical processing and operation temperatures. SOFC cathode materials such as LSCF, LSCF-GDC, LSM, LSM-YSZ were analyzed during this study. Material sintering behaviors (e.g., shrinkage, warpage, densification) and thermomechanical responses (e.g., viscosity, Poisson's ratio) were determined using CLD and CBB. These behaviors were observed at processing and operation conditions. A thorough understanding of the viscoelastic behavior of these systems over the range of processing and operational temperatures will enable prediction of the mechanical and microstructural stability of SOFCs and the accompanying cell efficiency and lifetime.