

Metal Interconnect Development – Design and Long-term Stability
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The SOFC interconnect must simultaneously satisfy several functional requirements. These functions require materials with high electronic conductivity for the series electrical connection of individual cells, gas impermeability to separate fuel and oxidant gases, chemical stability and conductivity over a large oxygen concentration range. In addition, thermal expansion match with the rest of the cell elements is desired. A metallic interconnect is very suitable in terms of achieving high electrical conductivity and gas impermeability. It also lends itself to ease of fabrication of gas channels by corrugation or by forming dimples on a planar structure. The use of a flexible metallic interconnect eliminates problems associated with the non-conformity of planar components. Greater control over dimensions helps improve the conformity as well as to provide uniform reactant distribution to ensure uniform current density and high fuel efficiency. High thermal conductivity of metal interconnects will help distribute the heat generated during the operation of the cell, thereby lowering the cooling air requirement as well as reducing sharp thermal gradients.

The use of metal interconnects, while well known, has posed considerable challenges. Typical austenitic or ferritic materials undergo rapid corrosion at the temperatures of SOFC operation, leading to large and unacceptable increases in resistance. While high Cr alloys match the thermal expansion coefficient of zirconia, the evaporation of Cr species was found to result in degradation in SOFC performance.¹ To mitigate this problem, the metal interconnect was coated with a perovskite such as lanthanum manganite or chromite, which imparts oxide scale conductivity and suppresses the Cr evaporation. In our work, ferritic alloys that form a Cr₂O₃ scale were found to offer good oxidation resistance with appropriate surface treatment, permitting their use in SOFC applications.

Interconnect Design

The challenges in interconnect development must be addressed using a combination of materials, processing, and design in order to achieve low cost and high performance. In contrast to conventional monolithic interconnects, a compliant interconnect design was developed.² The design allows separation of the structural and electrical functions, enabling selection of materials best suited to each function and atmosphere.

The interconnect is composed of four element types: a separator plate, edge seal rails, anode and cathode compliant structures, and conductive coatings. Different conductive coating and compliant structure materials are preferred for the air and fuel sides. The separator plate and edge seal rails are the only elements exposed to both the air and fuel atmospheres and their functions include isolation of air and fuel streams. The separator plate also conducts current as a conventional monolithic interconnect. Mechanical contact is made between the cell and separator plate by the compliant structure and the

edge seal rails. Electrical connection between the cell and separator plate may be made by the compliant structure directly, or by a conductive coating supported by the compliant structure. The compliant structure is a corrugation of perforated or expanded thin gauge metal. A conductive coating applied to the compliant structure on the air side. The anode side does not need such a coating on the compliant structure as nickel is typically used as the structure. Experience has shown that this design is much easier to fabricate than a monolithic metal design. This design allows selection of atmosphere-appropriate materials for flow channels, which retain some level of compliance.

Surface Treatment

Surface treatment of the native metal surface along with controlled oxidation was found to provide two benefits: well-adhered oxide scale and a significant reduction in oxide scale growth rate. The oxide scale was also found to provide an intimate interface with the perovskite coating that was applied and heat treated in a subsequent operation. Figure 1 shows the interfaces between the metal (left), oxide scale and the perovskite layer. Cobaltite and modified cobaltite layers were found to give interfacial resistance values of 10 to 20 milliohm.cm² in air at 850°C.

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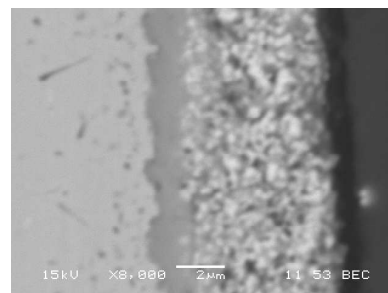


Figure 1: Metal-oxide-perovskite interfaces

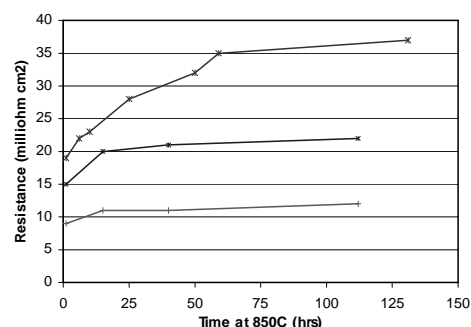


Figure 2: Interfacial resistance measured in air

References

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2. U.S. Patent 6,265,095 - Interconnect for solid oxide fuel cells.