Coatings for SOFC Interconnects

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Argonne National Laboratory
July 28-29, 2004

Outline

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Issues and Limitations of State-of-the-Art Materials

- No known bulk alloy that will meet all present performance, reliability, and cost requirements
  - Low ASR (< 10 milliohm square centimeter)
  - Minimal Cr volatilization and cathode poisoning
  - Good stability
    - Thermal cycling
    - Current conduction
    - Dual atmospheres (fuel and air)
  - Good CTE match between coating and substrate
  - Ability to produce in high volume at low cost
- Development of alternative alloys to meet requirements will take a long time and will require substantial investment
- It should be possible to develop coatings and surface modifications more quickly and at lower cost

Status – Coatings Under Consideration

- Perovskites
  - Short-term in-stack testing has shown performance benefits; tested at ~1000 hours at 800°C
  - Need more long-term durability testing
- Spinels Containing Ni, Cr, Al, Mn, Y, Ti & La
  - Physical vapor deposition (PVD) of spinels and carborundum
  - Under evaluation for SOFC application: ASR at 800 °C; thermal cycling and continuous test
  - Optimization of coating architecture, including functionally gradient coatings, multilayers and nanostructures
- Amorphous Metal Coatings
  - No devitrification at 800°C; devitrification at 1000 °C
  - Corrosion resistance in near-saturation boiling calcium chloride
- Other Potential Coatings
  - Magnetite (Concern with Further Oxidation)
  - Conducting Oxides: Zn; ITO (Thermal & Chemical Stability; Cost; Electrical Conductivity)
  - Oxide Glasses (Chemical Compatibility with Cathode & Substrate; Electrical Conductivity)

Development Needs – Coatings

- Financial support to develop formulations that are chemically compatible with cathode and substrate/interconnect
- Testing to demonstrate that coatings meet technical requirements
  - Low ASR (< 10 milliohm square centimeter)
  - Minimal Cr volatilization and cathode poisoning
  - Good stability
    - Thermal cycling
    - Current conduction
    - Dual atmospheres (fuel and air)
  - Good CTE match between coating and substrate
  - Adherence under cyclic thermal and mechanical load
- Economical processing for high volume production
  - Examples: Sol Gel; Physical Vapor Deposition; Chemical Vapor Deposition; Thermal Spray; Diffusion Saturation; etc.
  - Ability to meet SECA cost targets; detailed costing study; high-volume production at low cost
- Methods for in situ deposition assembled device
  - Examples: Sol Gel Process

Approach – Coatings

- Form integrated collaborative teams between SOFC industry, universities, and national (federal) laboratories
- Secure financial support from DOE to develop formulations that are chemically compatible with cathode and substrate/interconnect
- Establish formal selection criteria for design, synthesis, and characterization of acceptable new coating systems, including out-of-stack and in-stack testing
  - Low ASR (< 10 milliohm square centimeter)
  - Minimal Cr volatilization and cathode poisoning
  - Good stability during thermal cycling, current conduction, and in dual atmospheres
  - Good CTE match between coating and substrate
  - Adherence under cyclic thermal and mechanical load
- Selection and prioritization of most promising candidate coatings
- Explore new innovative concepts for economic production of coatings
  - Physical Vapor Deposition; Chemical Vapor Deposition; Thermal Spray; Diffusion Saturation; etc.
  - Methods for in situ deposition inside assembled devices, such as sol gel and PVD
- Testing to demonstrate that produced coatings meet technical requirements
- Demonstrate ability to meet SECA cost and technical performance and service-life targets; detailed costing study; high-volume production at low cost

Summary – Coatings

- Status
  - No alloy exists that meets all needs
  - A new alloy or coating is needed
  - Some coatings have shown promising performance in preliminary tests
  - Long-term durability has not yet been demonstrated
- Development Needs
  - Additional formulations are needed that satisfy chemical compatibility, mechanical and electrical property needs
  - Cost effective processes have to be developed for high-volume production of coatings
  - Research, development and engineering activities are all needed
- Approach
  - Form integrated collaborative teams between SOFC industry, universities, and national (federal) laboratories with frequent formalized interactions
  - Research with integration of results from different investigators
  - Demonstrate ability to meet SECA cost and technical performance and service-life targets

Contributions

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