Coatings for SOFC Interconnects

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Outline

• Issues and Limitations of State-of-Art Materials
• Status
• Development Needs
• Approach
• Summary
• Contributors
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 millohm 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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