Novel Composite Materials for SOFC Cathode Interconnect Contact

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OBJECTIVES

The overall goal of the research project is to develop a novel low-cost and damage-tolerant Ag-base alloy/perovskite composite material with low Ag evaporation/migration, suitable coefficient of thermal expansion, oxidation resistance, electrical conductivity, chemical stability and compatibility tailored compositionally and microstructurally for intermediate-temperature solid oxide fuel cell (SOFC) cathode-interconnect contact application. More specifically, the objectives of this research project include:

1) Elucidation of the mechanism of Ag evaporation at elevated temperatures;
2) Alloy design of new Ag alloys with significantly reduced Ag evaporation/migration;
3) Optimization of processing and microstructures of Ag alloy/perovskite composites;
4) Demonstration/assessment of performance of the new contact materials.

ACCOMPLISHMENTS TO DATE

Through a systematic experimental evaluation of various factors affecting the evaporation rate of pure Ag, the Ag evaporation mechanism has been elucidated. In addition, we have identified the optimal conditions for evaluating the Ag evaporation of Ag-based alloys and composites as contact material: exposure environment - flowing air; air flow rate - 1.5 $cm.s^{-1}$; exposure temperature - 850°C; exposure time - 40 hours. A number of Ag-base alloys have been prepared using both the arc-melting and drop-casting technique and the powder metallurgical route. These alloys were pressed into 1-mm sheets for Ag evaporation testing. Pd, Pt, and Au have been found to be effective in reducing the Ag evaporation rate; however, these elements are too expensive. Current research efforts are focusing on identifying effective, low-cost alloying additions.

A new route for synthesizing a well-distributed Ag+peroviskite composite with an average particle size of about 1 µm has been developed, starting with commercial Ag and perovskite powders. The powders with the desired Ag-to-perovskite ratio were mixed with an ink vehicle to form a paste for screen printing. A uniform, well-bonded contact layer of 20-50 µm thick has been achieved between the interconnect alloy (e.g. Crofer 22 AUP) and the porous cathode - $(La,Sr)MnO_3$.

The construction and evaluation of the interconnect/contact/cathode test assembly have been streamlined for assessing the performance of the Ag-perovskite composite contact material. A special device has been designed and assembled for optimizing the screen-printing process used to deposit the porous cathode and the composite contact material. The test rig configuration for evaluating the electrical conductivity as well as the thermal cycling resistance of the contact material in direct contact with both the cathode and the interconnect alloy has been identified. Using the new test rigs, extensive evaluation of the performance of various Ag-perovskite composite contact materials is underway. Initial results indicate that the composite contact layer is effective in reducing the Cr migration from the interconnect to the porous cathode.

FUTURE WORK

A number of binary and ternary Ag alloys as well as Ag-perovskite composites with different Ag-to-perovskite ratios will be prepared and the Ag evaporation rate of these materials will be measured and potential alloying elements and the desired Ag-to-perovskite ratios in the composite will be identified. Electrical characterization and thermal cycling of the interconnect/contact/cathode test assembly will be continued to identify the desired Ag-to-perovskite ratio for achieving stable electrical conductivity of the assembly. The interaction of the contact materials with the interconnect and cathode materials will be assessed by examining the thermally-exposed test assembly to identify possible interfacial phase formation and the extent of interdiffusion. The effectiveness of the contact materials on blocking Cr migration from the interconnect alloy to cathode will be demonstrated.

LIST OF PAPER PUBLISHED, CONFERENCE PRESENTATIONS, STUDENTS SUPPORTED UNDER THIS GRANT

Publications:

- “Evaporation and Thermal Etching of Pure Ag at Elevated Temperatures”, Z.G. Lu and J.H. Zhu (manuscript to be submitted to J. Electrochem. Soc.)

Conference Presentations:

- “Evaporation of Pure Ag under SOFC Operation Conditions”, Z.G. Lu and J.H. Zhu, Presented at the Symposium Fuel Cells and Energy Storage Systems: Materials, Processing, Manufacturing and Power Management Technologies, MS&T 06, Cincinnati, Ohio, October 15-19, 2006
- Conference Presentation: “Development and Characterization of Ag-LSCF Composite Contact Material for SOFC", Presented at the Symposium Fuel Cells and Energy Storage Systems: Materials, Processing, Manufacturing and Power Management Technologies, MS&T 06, Cincinnati, Ohio, October 15-19, 2006

Student Supported Under this Grant:

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