

A COMPARISON OF Cu-CERIA-SDC AND Au-CERIA-SDC COMPOSITES FOR SOFC ANODES

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Introduction

Direct-oxidation solid oxide fuel cells (SOFCs) have the potential to simplify system design and reduce system cost. An essential requirement for the direct oxidation of dry hydrocarbon fuels in an SOFC is to eliminate deleterious carbon deposition on the anode (1). Because of its inertness for C-H bond breaking, Cu has been selected to replace Ni that is highly active for carbon formation and used in conventional anodes. To compensate the anode-activity loss without Ni, ceria is included in the anode as a catalyst to enhance the activity for the oxidation of hydrocarbon fuels. It has been shown that Cu-ceria-YSZ anodes are capable of directly operating with a variety of hydrocarbon fuels (2-4).

Recently, the feasibility of direct oxidation of hydrocarbons at intermediate temperatures has also been demonstrated using Cu-ceria-SDC (samaria doped ceria) anodes supported on SDC electrolyte (5). It has been assumed that the primary function of Cu in these anodes is to conduct electrons away from the triple phase boundary where electrons, oxygen ions and fuel are available for electrochemical reactions. However, since Cu is known to be an active catalyst for the water-gas-shift reaction and for methanol synthesis (6), it is conceivable that Cu is also important catalytically in the anodes. To test for this, we have prepared a cell with an anode prepared from Au, ceria, and SDC and compared its performance with a similar cell having an anode prepared from Cu, ceria, and SDC. Since Au is unlikely to exhibit any catalytic activity, one should expect to see differences between the cells having Cu-ceria-SDC and Au-ceria-SDC anodes if the catalytic properties of Cu are important. As we will demonstrate, the performance of the two cells in H₂ and n-butane is essentially identical. This observation supports the earlier assumption that Cu is primarily an electronic conductor in the Cu-based anodes and that the catalytic properties of Cu are not crucial in direct-oxidation anodes.

Experimental

SDC-electrolyte supported SOFCs with porous metal-ceria-SDC anodes were prepared using a pressing method detailed elsewhere (5), and the anode composition for each cell was detailed in table 1. Cell current-voltage (IV) plots and impedance spectra with hydrogen and butane fuels were measured using a Solartron 1287 electrochemical interface and a Solartron 1250 frequency response analyzer. After electrochemical measurements, the cell microstructures were characterized using a JEOL 6400 SEM. The SEM results indicated that the major difference among the cells was the anode composition. Consequentially any differences in the cell performance could be related to the differences in anode composition.

Results and Discussion

Fig. 1 displays the cell voltage and power density as a function of current density for dry butane fuel. The OCV of cell 2 is slightly higher than that of cell 1; however, the OCVs are lower than their theoretical values. This can be attributed to the mixed electronic-ionic conductivity in the SDC electrolyte. The maximum power density of cell 1 with the Cu-ceria-SDC anode is 47.6 mW/cm² and is nearly identical to that of cell 2 with the Au-ceria-SDC anode. The similar performance characteristic for cells 1 and 2 indicates that the Cu-ceria-SDC and Au-ceria-SDC anodes possess comparable activity for the oxidation of C₄H₁₀. Cell 3 with the Au-ceria-SDC anode displays the worst performance with C₄H₁₀ fuel, and this is most likely due to changes in the ceria layer and loss of catalytic activity that take place during the Au impregnation step.

Fig. 2 shows cell impedance spectra for dry C₄H₁₀ fuel. Our previous study suggested that the amplitude of the low-frequency lobe could be used as a measure of the anode activity for fuel oxidation (5). Therefore, the similarity of the low-frequency lobes, for the Cu-ceria-SDC anode in the cell 1 and the Au-ceria-SDC anode in the cell 2 indicates similar activity for C₄H₁₀ oxidation. This result is consistent with the IV curves presented in Fig. 1.

The above comparison between Cu-ceria-SDC and Au-ceria-SDC anode cells indicates that both anodes have comparable activity for the oxidation of C₄H₁₀ fuel. This result demonstrates that Cu and Au have similar functions in the anodes. Since Au is an inert metal with almost no catalytic activity, the catalytic activity of Cu in the anode must also be negligible.

Conclusions

The results of this study indicate that Cu is simply an electronic conductor in Cu-based anodes that are being developed for direct-oxidation SOFC. Given that anodes made with Au in place of Cu showed similar electrochemical performance, it is unlikely that the catalytic properties of Cu are important in this application. Finally, it is again demonstrated that ceria plays a crucial role in maintaining high performance in these direct-oxidation anodes.

Acknowledgements

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Table 1. Summary of cell parameters

Cell	Anode			
	Composition		Porosity (vol%)*	Thickness (micron)
	Metal (vol%)	Ceria (vol%)		
1	Cu; 23	10	50	150
2	Au; 25	10 + 15**	50	140
3	Au; 24	10	49	140

* Before impregnation of the metal and ceria

** 15 vol% ceria, impregnated after Au loading

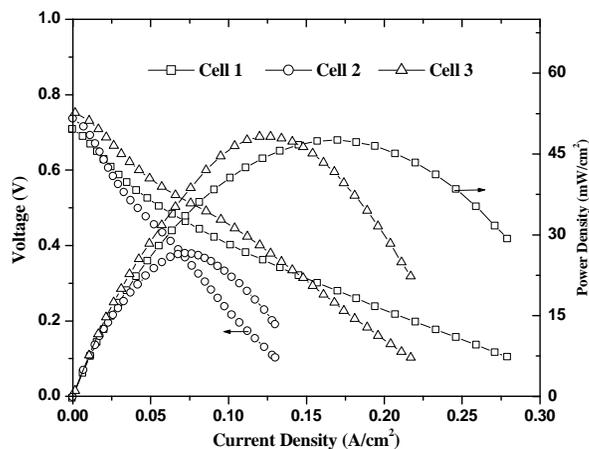


Fig.1 Cell I-V and I-P curves with butane fuel at 650°C

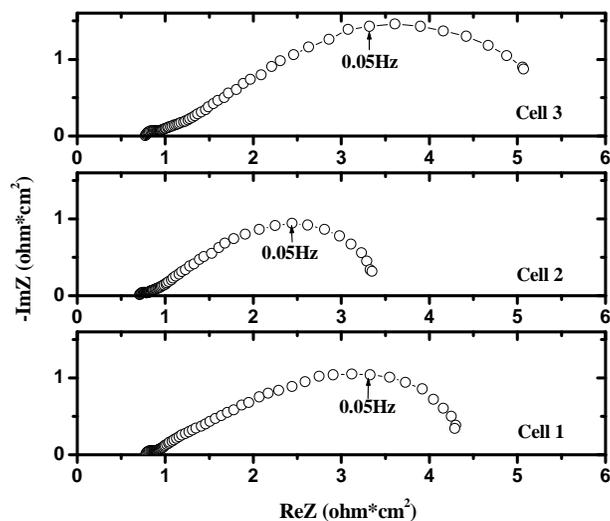


Fig.2 Cell impedance spectra with butane fuel at 650°C