

Determine the operating conditions to minimize carbon deposition on anode catalyst

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Introduction

When solid oxide fuel cells (SOFCs) operate in hydrocarbon, several prospective anode materials suffer serious degradation due to the carbon deposition as well as hydrogen sulfide poisoning. The conventional anode material, Ni-YSZ, suffers serious coking when operated directly on hydrocarbon and it either reacts rapidly with H₂S to form a sulfide or poisons the catalyst surface, even at low concentrations [1]. Therefore, developing sulfur and carbon tolerant anode materials becomes imperative. Much work has been done on the alternative anodes that can endure harsh environment. Perovskite structure materials are the promising Ni-free anode candidates due to their high chemical stability, strong resistance to carbon deposition and sulfur poisoning [2]. In this work, the effects of operating conditions and humidified fuel on coking were studied to optimize the conditions for decreasing the carbon deposition of the cell in 5000 ppm H₂S-containing CH₄.

Experimental

Fuel cells were fabricated using commercial YSZ disks as the electrolyte. The porous anode of YSZ layer was tape casting on the electrolyte first, and then impregnated with the LSBT precursor solution in vacuum and heat treated at 800 °C for 1 h in air for 6 times. The method of preparing LSBT precursor solution was reported in [3]. The equal amounts of YSZ and LSM were applied as the cathode using tape casting. The membrane electrode assemblies were calcined at 1200 °C for 1 h in air.

The cells were tested at different current densities, voltages, temperatures and water concentrations in 0.5% H₂S-CH₄ feed.

Results and discussions

Figure 1 shows the cell potentials tested at different current densities. The electrochemical performance is stable at 40 mA/cm². At 60 mA/cm², the performance was improved gradually. However, higher current density, i.e., 80 mA/cm², led to degradation of the cell performance at 850 °C. A small amount of deposited carbon at the moderate current density can increase the electronic conductivity and improve the performance at the same time. At higher current, more carbon deposited on the anode surface, which blocked the active sites and led to the high degradation rate.

Adding water vapor (3%-6%) in the anode feed suppressed the carbon deposition but decreased the fuel cell performance (Figure 2). When the water vapor pressure increased in the feed gas (H₂O% > 6%), more H₂O was absorbed onto the anode catalyst and blocked some active sites, resulting in the degradation of the fuel cell performance. The performance of the cell could be recovered when dry fuel was re-fed. The result showed that the deposited carbon could be removed by introduction of water to the dry anode fuel.

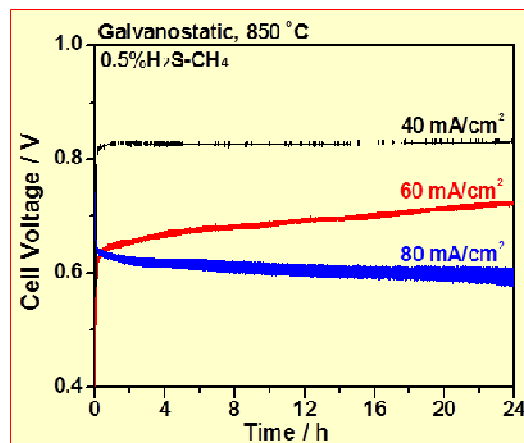


Figure 1. The cell voltage as a function of time tested at different current density at 850 °C in 0.5% H₂S-CH₄.

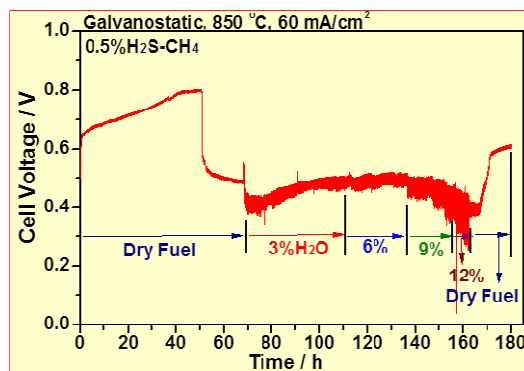


Figure 2. The cell voltage as a function of time tested at 60 mA/cm² in different water-content 0.5% H₂S-CH₄ at 850 °C.

References

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3. A. L. Vincent, A.R. Hanifi, J.L. Luo, K.T. Chuang, A.R. Sanger, T.H. Etsell, P. Sarkar, J. Power Sources 215 (2012) 301-306.