Sulfur Tolerant Materials for Hydrogen Sulfide Solid Oxide Fuel Cells

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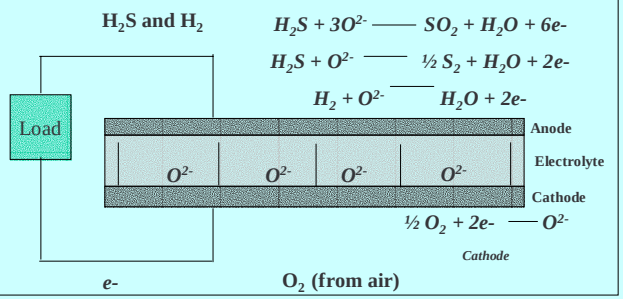
Introduction

Each year the US alone produces over twelve million tons of hydrogen sulfide mainly as an industrial by-product in the refining of fossil fuels. Due to the lack of commercial use for H_2S, virtually all of it is converted to sulfur in the Claus Process, where a partial oxidation with air produces elemental sulfur at around 1100^{0}C with sulfur recovery of about 95%. However, it would be much more desirable to electrochemically oxidize H_2S in a fuel cell, to simultaneously produce electricity, high-temperature steam, and concentrated sulfur dioxide. The SO_2 reaction product may be used in the manufacture of sulfuric acid and sodium hydrosulfite, both high-volume commodity chemicals. An additional application for this technology is the ability of SOFC devices to operate on hydrocarbon fuels. H_2S has a catastrophic effect on typical anode materials for SOFCs. Sulfur poisoning is responsible for severe degradation in fuel cell stability and performance, making most conventional SOFC anode materials useless even at very low concentrations.

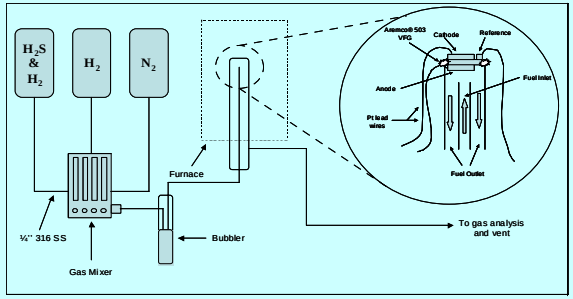
Our main objective was to develop new sulfur tolerant materials for SOFC anodes. We have characterized the performance of novel ceramic materials in an H_2S atmosphere as well as the effect of process variables (time, temperature, etc.) on the sulfur poisoning effect. Our work is ultimately aimed at achieving direct electrochemical oxidation of H_2S at the fuel cell anode in an efficient and reliable SOFC system. In this poster, we report our recent results using a new class of anode materials for the oxidation of H_2S or practical hydrocarbon fuels containing H_2S in a SOFC.

H_2/H_2S SOFC Operation

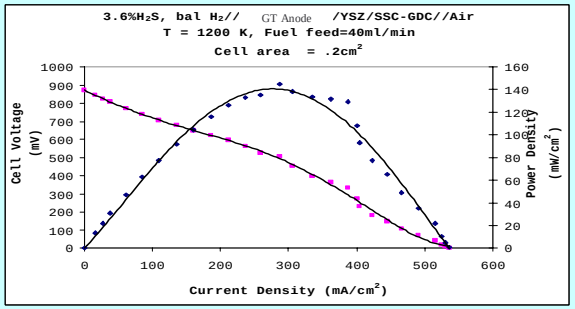
Electrochemical Reactions



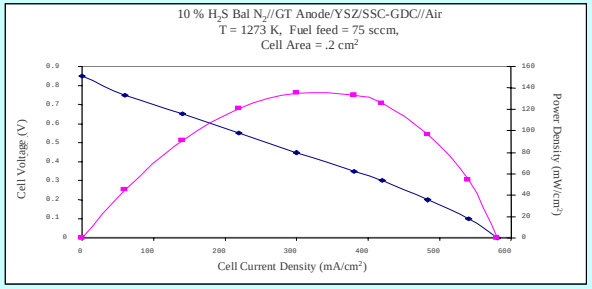
Fuel Cell Testing Apparatus



Cell Performance - H_2 with 3.6% H_2S

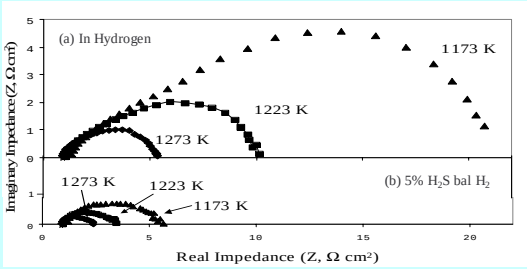


Cell Performance - H_2S



Typical Impedance Spectra

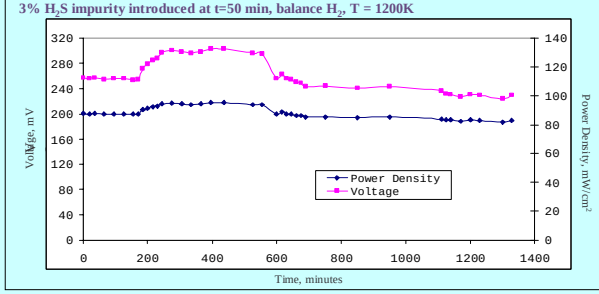
GT ANODE exposed to (a) pure H_2 and (b) 5% H_2S bal H_2 at different temperatures



Long-Term Stability

GT ANODE, SSC-GDC Cathode, 8% YSZ Electrolyte of 200 μm thick

3% H_2S impurity introduced at t=50 min, balance H_2, T = 1200K



Conclusions

Preliminary results indicate that these anodes are stable and active towards the electrochemical oxidation of H_2S. In particular, an SOFC using the novel materials as the anode has shown good performance at H_2S levels of 10%, over 5000 times greater than the H_2S tolerance level of Ni based systems. The results are promising due to the drastic improvement in sulfur tolerance compared to the current generation of SOFC anode materials. The long-term performance of these materials in SOFCs under practical conditions is yet to be determined.

Acknowledgement

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