Corrosion of Metallic Interconnects in a Pressurized SOFC

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Background

- Interconnects in a SOFC act as current collectors, gas flow fields and also as anode - cathode separators in a stack.
- Decrease in operational temperature of SOFC has lead to the use of cost effective Fe and Chromium based alloys as interconnects.
- Crofer 22 APU and Ebrite are commercial interconnects that are widely in use.
- Operation of an SOFC in pressurized conditions increase the fuel utilization up to 75% leading to improved performance.
- Pressure increases the kinetics and performance in fuel cell operation.

*Nguyen Minh, Honeywell Inc., Texas Hybrid Meeting, Galveston TX, Feb 2002.
Problem Description

• Requirements for Metallic Interconnect
  – High temperature oxidation resistance
  – Compatible thermal expansion with ceramic electrodes.
  – Electrically conductive oxide scale.
  – Low cost

• Problem definition
  – Oxide scale growth decreases electrical conductivity and increases the resistance across the stack.
  – The oxide scale is primarily composed of oxides of chromium which oxidizes in the oxygen rich cathode atmosphere leading to the formation of volatile Cr(VI) oxides and oxyhydroxides.
  – The oxyhydroxide is expected to deposit at the electrolyte-cathode interface as Cr$_2$O$_3$ leading to decrease in performance.

\[
\text{Cr}_2\text{O}_3 + \frac{3}{2} \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{CrO}_2(\text{OH})_2
\]

  – Under operation in pressurized conditions, we expect the degradation to increase and it is essential to study this effect.
Objective

The objectives of the proposed research is to evaluate the performance and the corrosion properties of chromium alloys (Ebrite and Crofer 22 APU) used as interconnects in a SOFC operated at various pressures. Specific objectives being:

- Study the degradation of metallic interconnects as a function of temperature, pressure and duration.
- Evaluate the electrochemical and material properties of the scale growth.
- Attain better insight into the corrosion processes occurring at the interfaces and establish the corrosion mechanism.
- Suggest methodologies to reduce the corrosion of metallic interconnects.
Approach

**Parameters**
Temperature, Pressure, Duration

Corrosion of Metallic Interconnects in Oxidizing Atmosphere

**Electrochemical Characterization**
- Electrical conductivity
- Area Specific Resistance
- EIS measurements

**Material Characterization**
- XRD, SEM
- Cross section EDS, EMPA
- Raman

Characterize

Propose Corrosion Mechanism

Suggest methodologies to reduce corrosion of metallic interconnects

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Tasks

- Perform durability tests on interconnect materials in a tubular reactor filled with oxidizing atmosphere which will mimic the SOFC environment at various pressure.
  - Corrosion of metallic interconnects and interconnects coupled with the cathode materials will be studied
  - Estimate the metal loss from weight change measured before and after accelerated tests as a function of temperature, pressure and duration.

- Electrochemical Characterization
  - Measure electrical conductivity/reistivity by DC four probe method.
  - Measure area specific resistance
  - Characterize the scale with electrochemical Impedance measurements.

![Fig: Schematic for ASR measurements]
Tasks

• Material Characterization of oxide scale growth.
  – XRD analysis will be performed to estimate the structural changes due to corrosion.
  – Cross sectional SEM to estimate thickness of interfacial oxide growth
  – EPMA and EDS spectra across the cross section will be used to analyze the oxide layer and amount of chromia diffused in to the cathode.
  – Raman and FTIR studies will be used to support the findings.

• Propose corrosion mechanism based on the analysis of electrochemical and material characterization studies.
Key Deliverables

• Participation in coordination meeting.

• Characterize oxide growth in Ebrite and Crofer under pressurized conditions using a coupon test at 700°C and 800 °C.

• Characterize chromia poisoning of the LSM and/YSZ cathodes by Ebrite and Crofer interconnect materials under pressurized conditions using SOFC module degradation tests at 700°C and 800 °C.

• Perform microstructural and chemical analysis of tested samples and correlate microstructure with the electrical and electrochemical measurements.

• Provide timely inputs to HPGS for report writing activities.