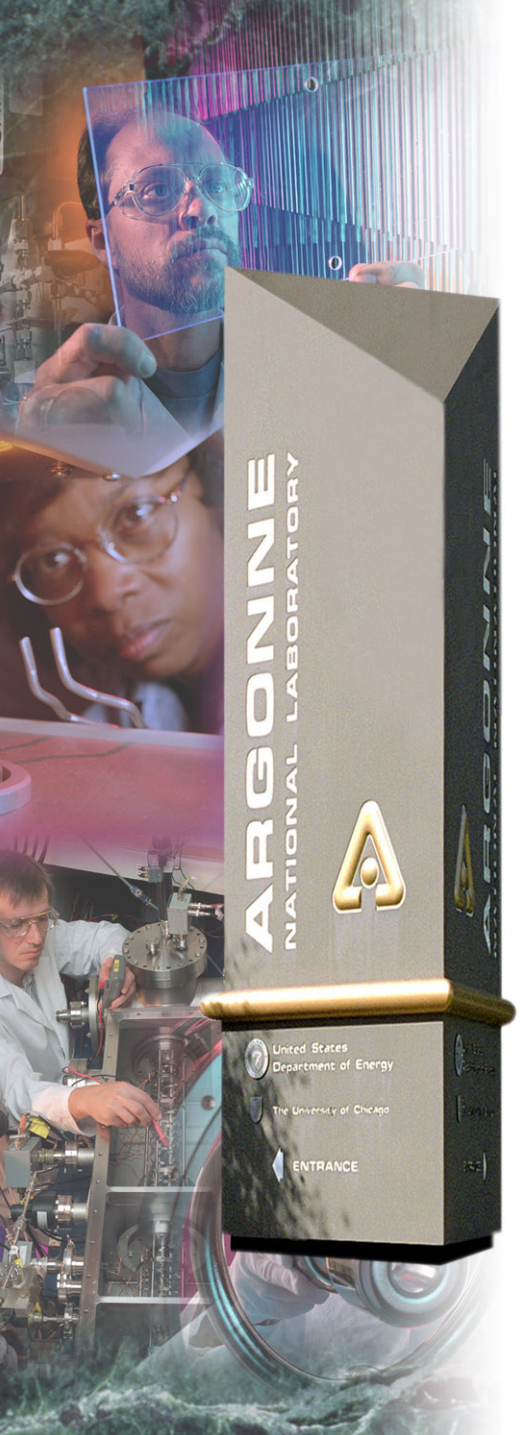

Cathode/Interconnect Interactions

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Introduction

Chromium produces an irreversible decline in SOFC performance.

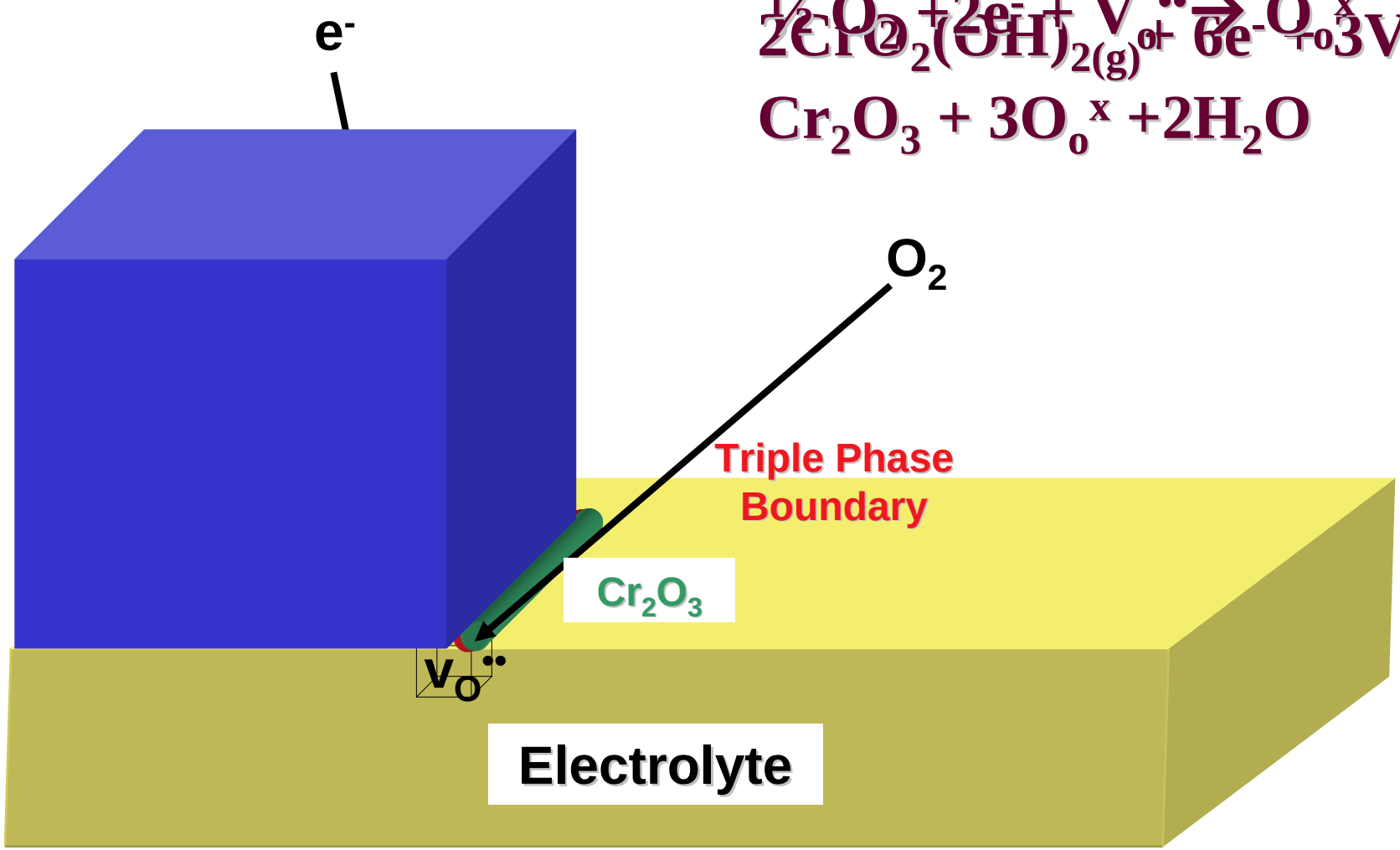
$$2Cr + 1.5O_2 \rightarrow Cr_2O_3$$

$$Cr_2O_3 + O_{2(g)} + H_2O_{(g)} \rightarrow 2CrO_2(OH)_{2(g)}$$

Electronic Conducting Cathode

$$\tfrac{1}{2}O_2 + 2e^- + V_o^{\bullet\bullet} \rightarrow O_o^x$$

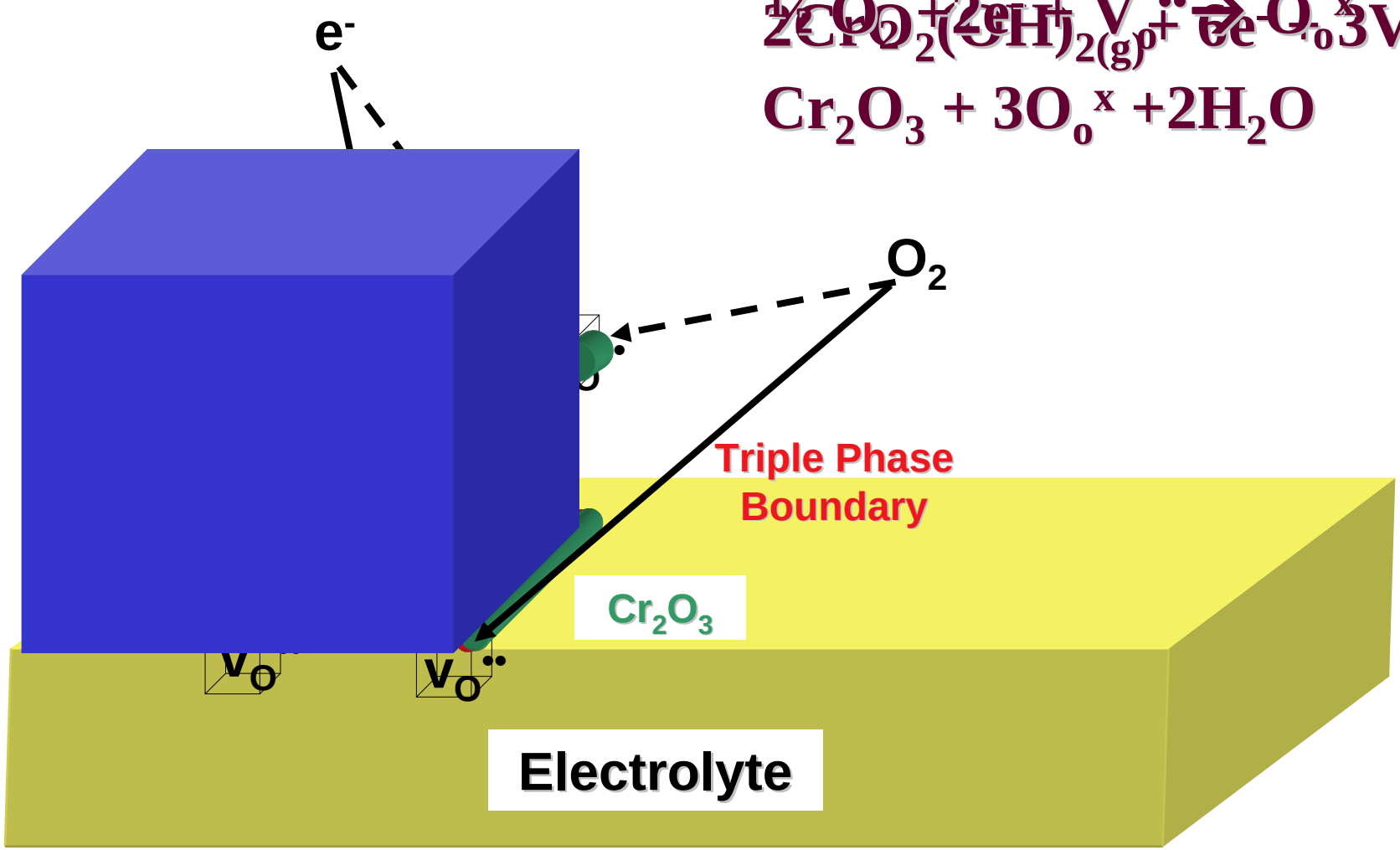
$$2CrO_2(OH)_{2(g)} + 6e^- + 3V_o^{\bullet\bullet} \rightarrow Cr_2O_3 + 3O_o^x + 2H_2O$$



Mixed Conducting Cathode

$$\tfrac{1}{2}O_2 + 2e^- + V_o^{\bullet\bullet} \rightarrow O_o^x$$

$$2Cr_2O_2(OH)_{2(g)} + 3V_o^{\bullet\bullet} \rightarrow Cr_2O_3 + 3O_o^x + 2H_2O$$



Program Objectives

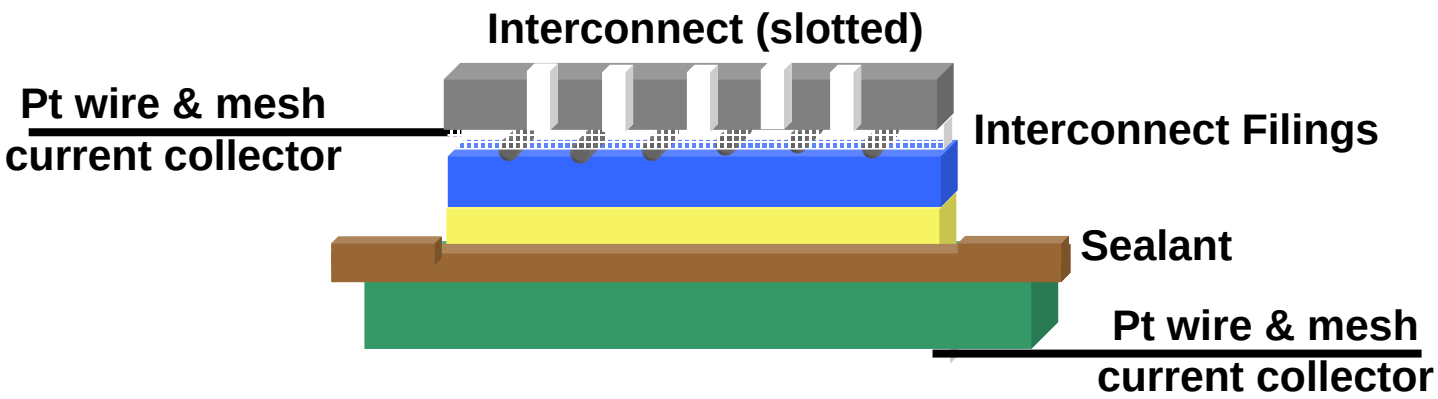
- **Examine chromium poisoning in full cell tests**
  - Different Cathodes
    - *$(La,Sr)MnO_3$, $(La,Sr)FeO_3$ and $(La,Sr)_{1-x}FeO_3$*
  - Different Alloys
    - *430 SS, E-BRITE and Crofer 22APU*

- **Evaluate chromium release rates for oxides**
  - Cr_2O_3
  - $LaCrO_3$
  - $MnCr_2O_4$

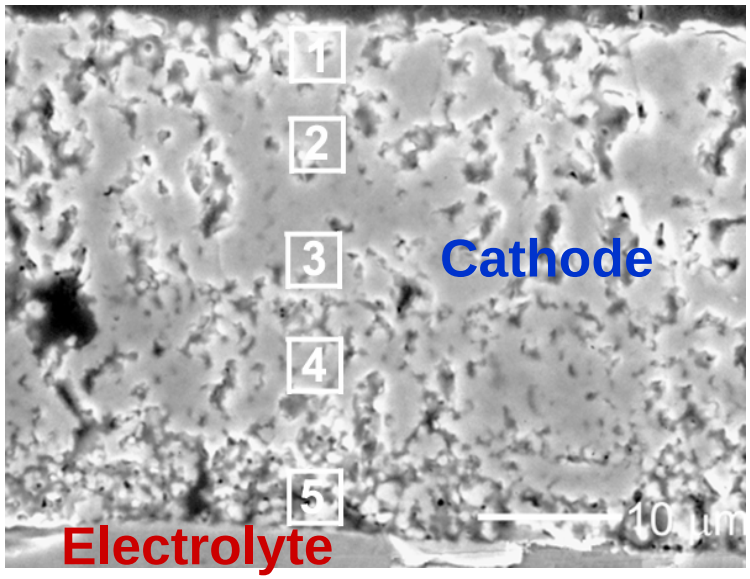
- **Examine the effects of chromium in the cathode**

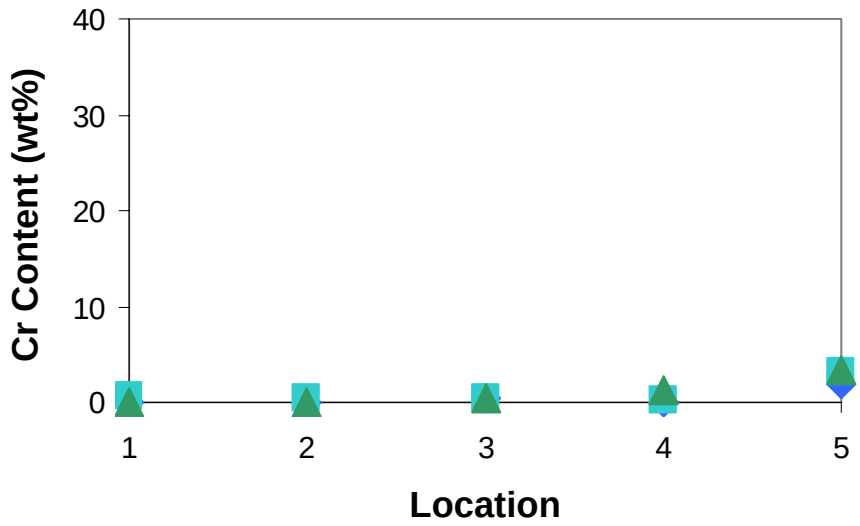
Full Cell Test Procedure

- **Anode supported cells, with various cathodes, mounted into test fixture (purchased from InDec and NexTech)**
- **Cell operated at 0.7V, current measured**
- **Test stopped when current reduced to ½ initial value**



LSM with Crofer22APU





Temperature: 800°C

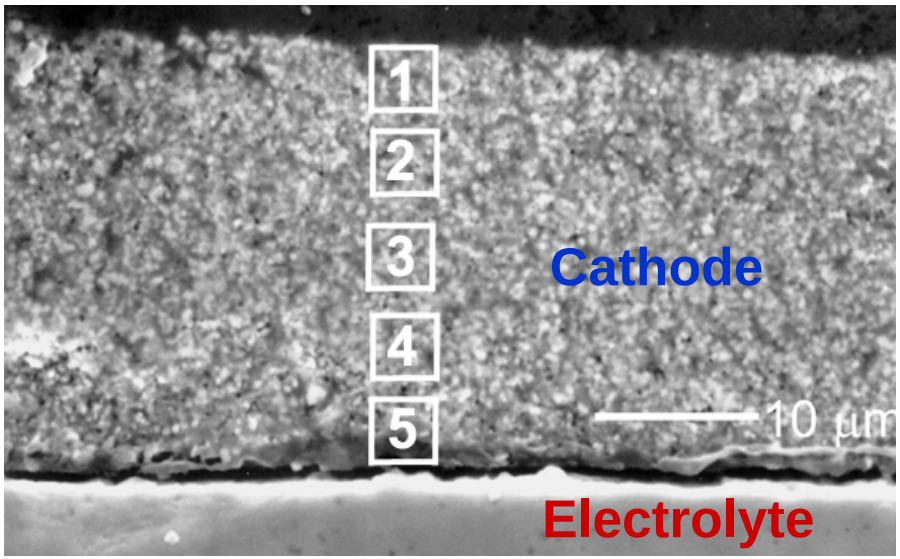
Run Time: 194 hours

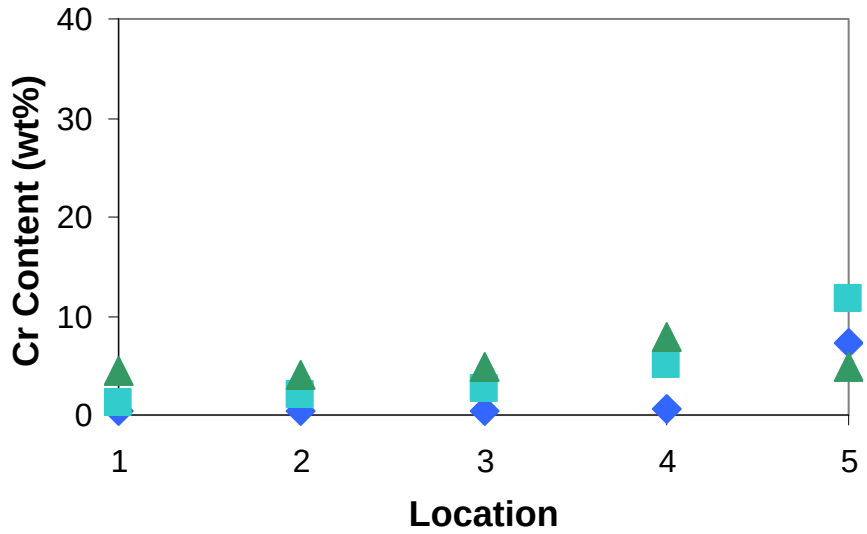
Flow rate: 100 ml/min

Cathode gas: Air with room temp. humidification

Anode gas: Hydrogen with room temp. humidification **Cell Source: InDec**

LSF with Crofer22APU





Temperature: 800°C

Run Time: 48 hours

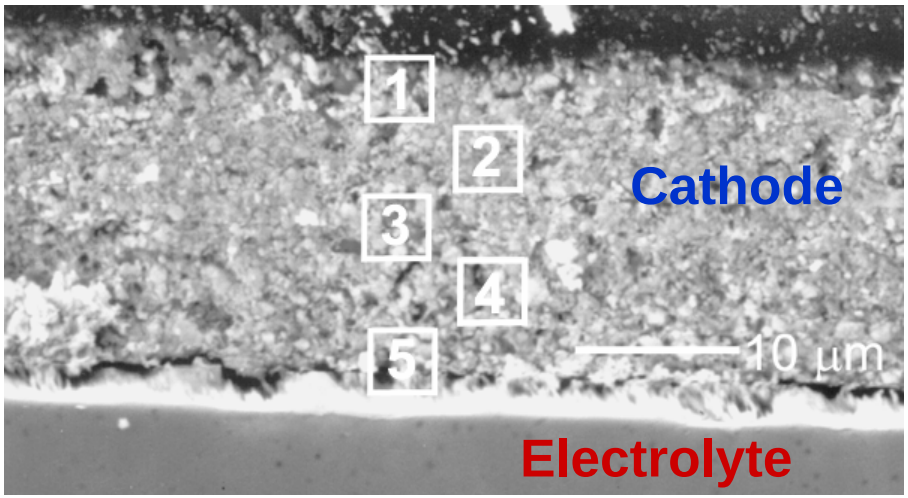
Flow rate: 100 ml/min

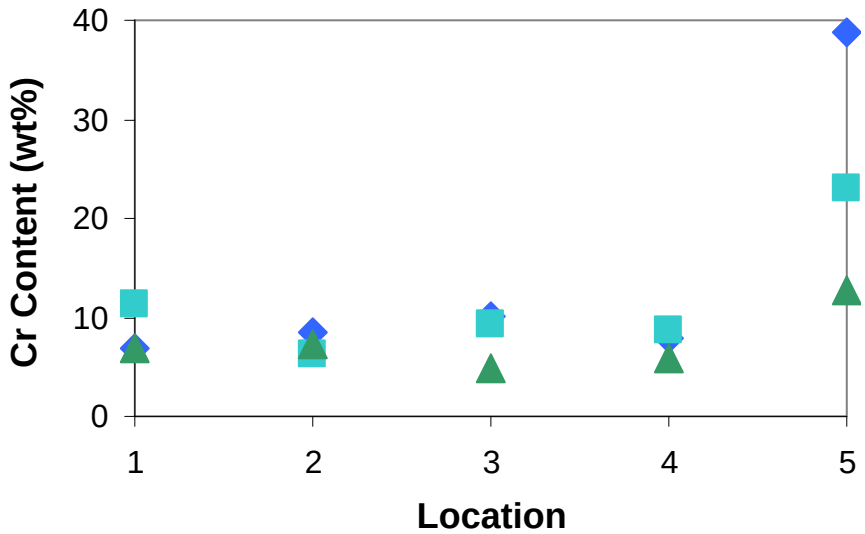
Cathode gas: Air with room temp. humidification

Anode gas: Hydrogen with room temp. humidification

Cell Source: NexTech

LSF_{sub} with Crofer22APU





Temperature: 800°C

Run Time: 58 hours

Flow rate: 100 ml/min

Cathode gas: Air with room temp. humidification

Anode gas: Hydrogen with room temp. humidification **Cell Source: NexTech**

Summary of Crofer Full Cell Tests

- **Cr content highest at cathode/electrolyte interface**
- **Cr throughout the LSF and LSF_{sub}**
- **Cr content correlates with oxygen ion vacancy concentration**
  - $LSM < LSF < LSF_{sub}$

$$2CrO_2(OH)_{2(g)} + 6e^- + 3V_o^{\bullet\bullet} \rightarrow Cr_2O_3 + 3O_o^x + 2H_2O$$

TGA Objectives

- **Establish steady state reaction conditions similar to what may be seen in a fuel cell**
- **Measure the rate of material lost from various possible sources of chromium**
- **Compare results with the amount of chromium observed in the cathodes**

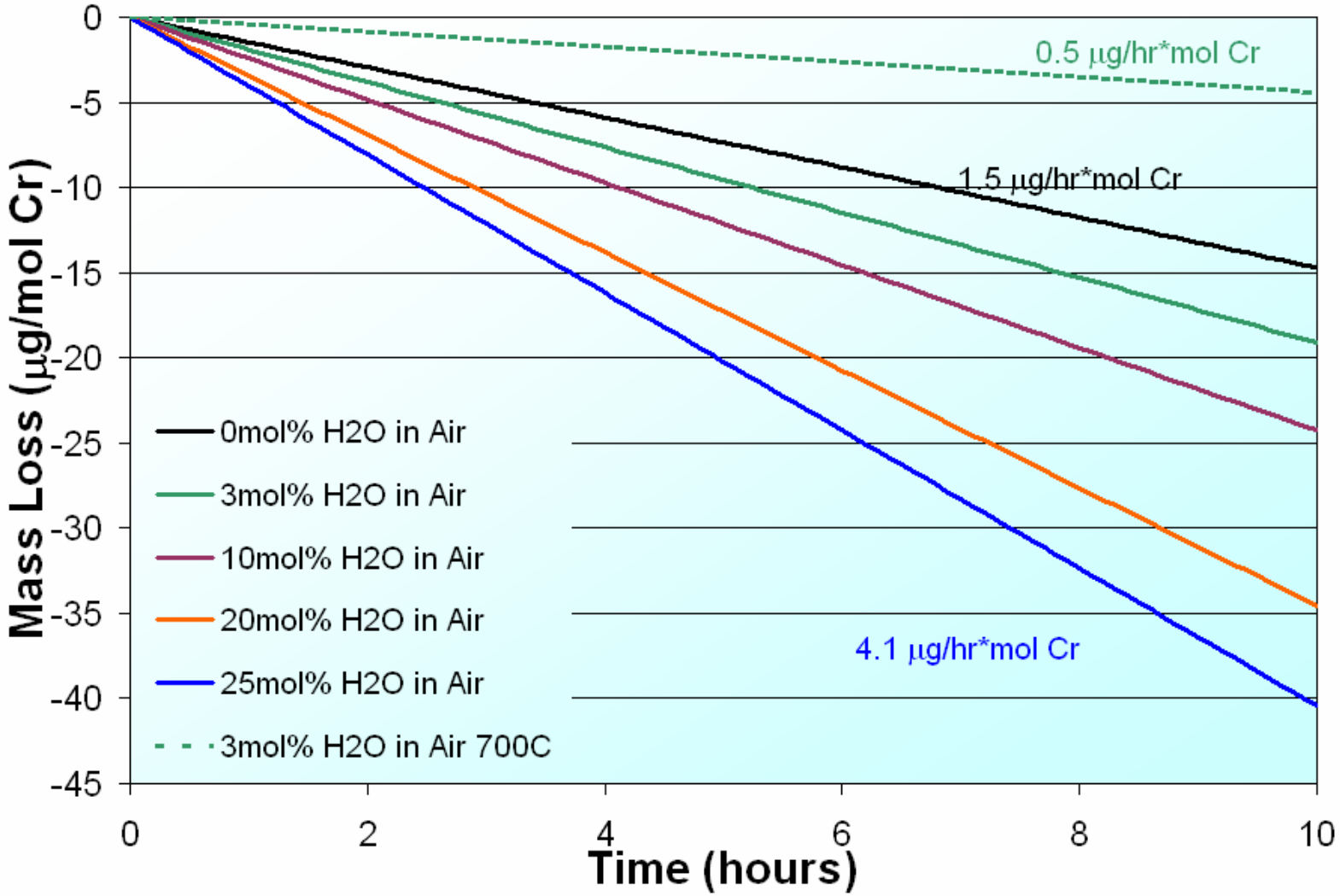
Based on Thermodynamics

- **Predominate volatile species**
  - Air, dry: CrO_3
  - Air, with H_2O: $CrO_2(OH)_2$

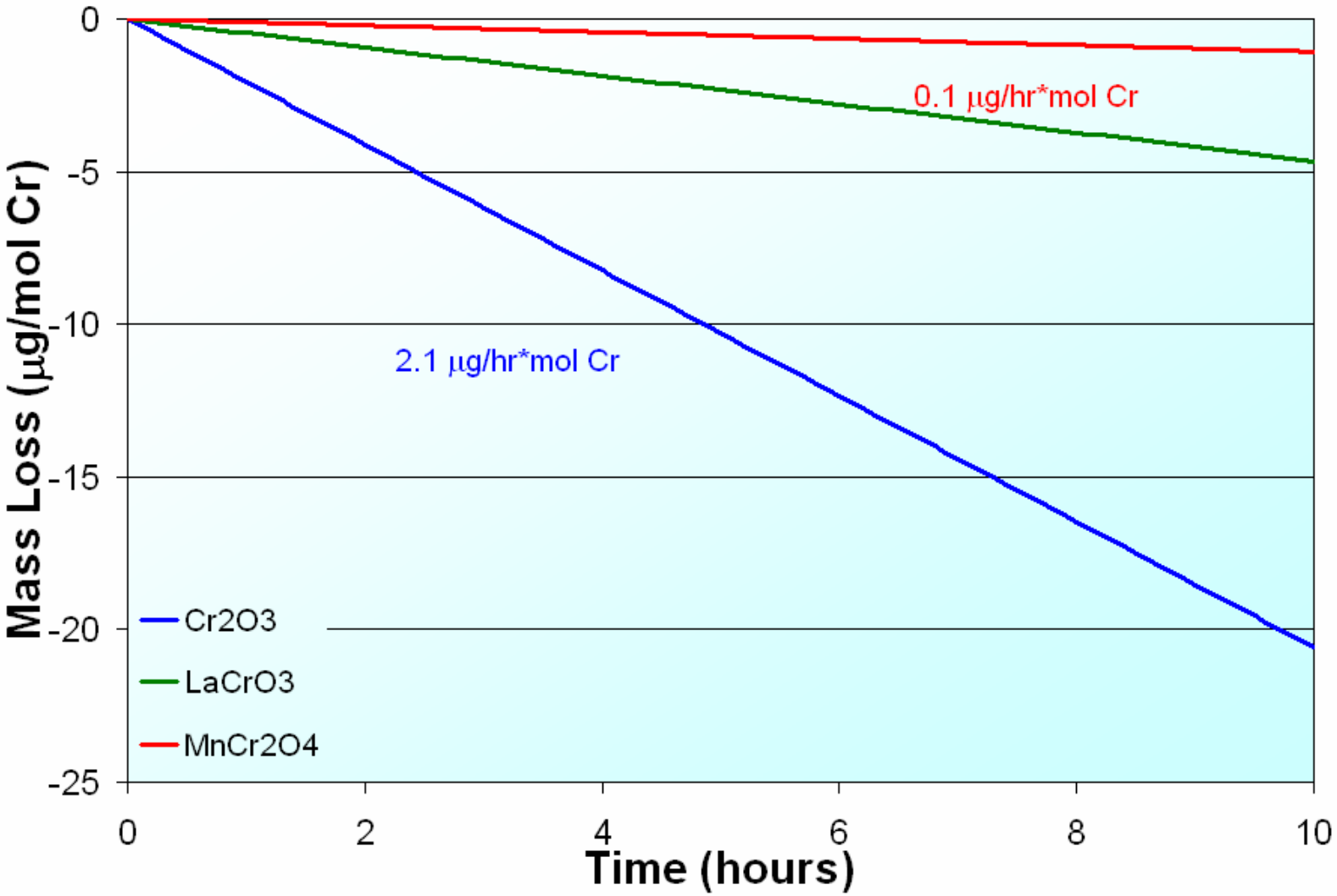
- **At 800°C: $CrO_2(OH)_2$ ~100x greater than CrO_3**

- **At 800°C $LaCrO_3$ & $MnCr_2O_4$ ~100x more stable than Cr_2O_3**

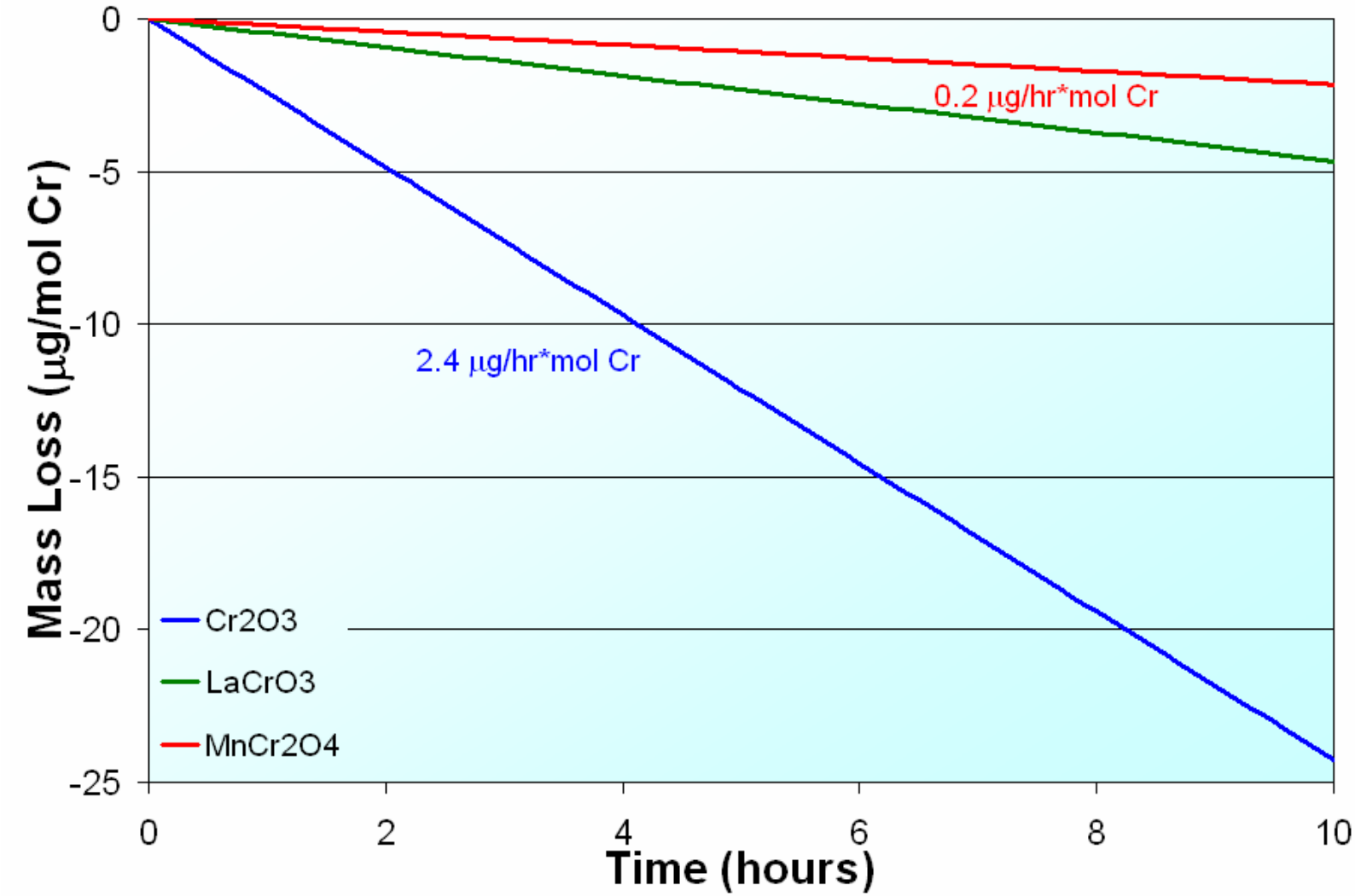
Effects of Water on Cr_2O_3 at 800°C



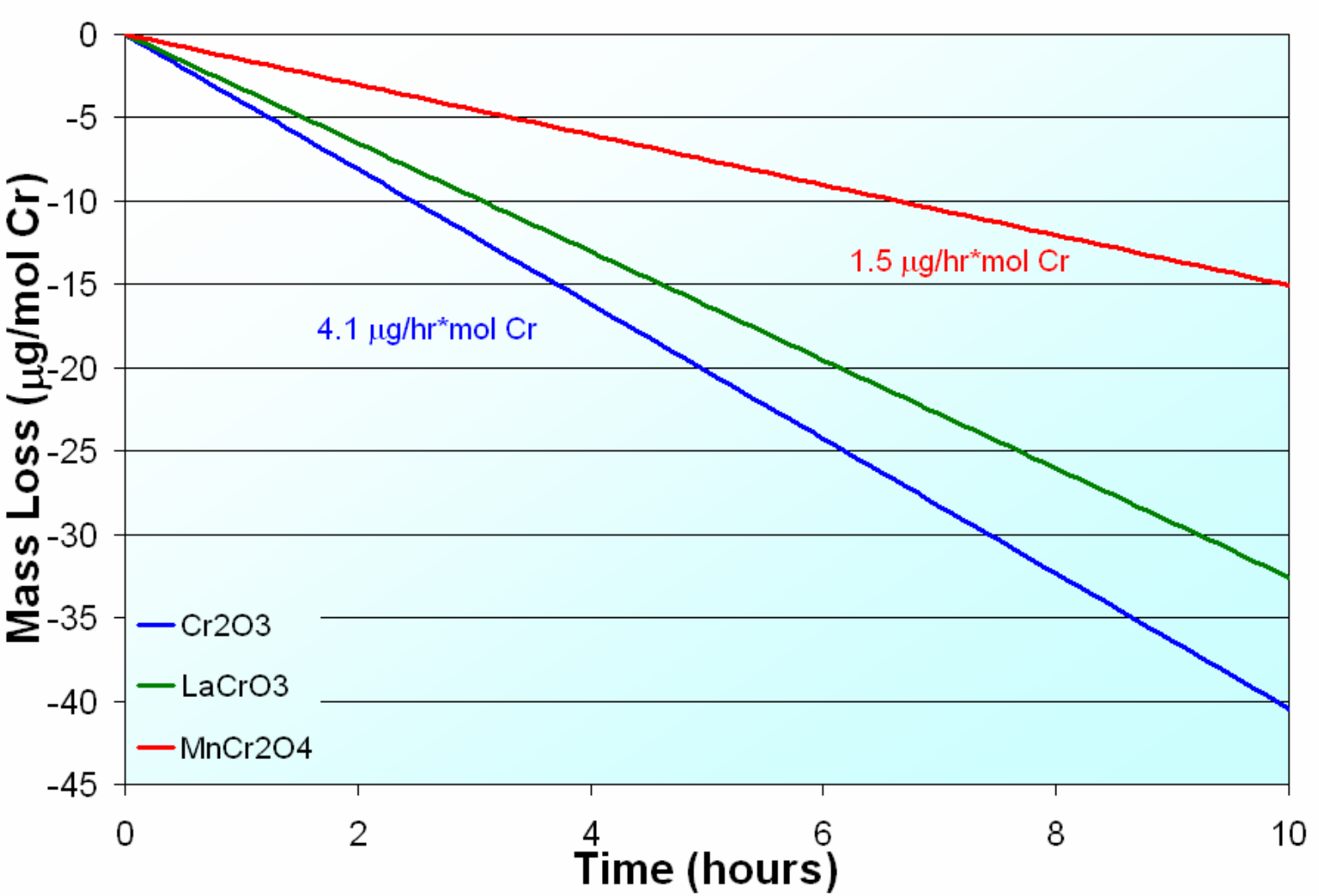
Air-3% H_2O, 800°C



Air-10% H_2O, 800°C



Air-25% H_2O, 800°C



Correlation of TGA and Cell Experiments

- **Projected Cr release based on TGA results for Cr_2O_3 scale after 200 hrs**
  - ~ 5000 μg Cr volatilized

- **Average Cr content of cathodes based on SEM/EDS analysis**
  - LSM ~ 150 μg Cr
  - LSF ~ 800 μg Cr
  - LSF_{sub} ~ 1200 μg Cr

Summary of TGA

- **Increasing humidity and temperature, increased volatilization**

- **Mass loss rate**

  Cr_2O_3> $LaCrO_3$ > $MnCr_2O_4$

- **Continue examining**
  - variations in composition
  - temperature
  - humidity

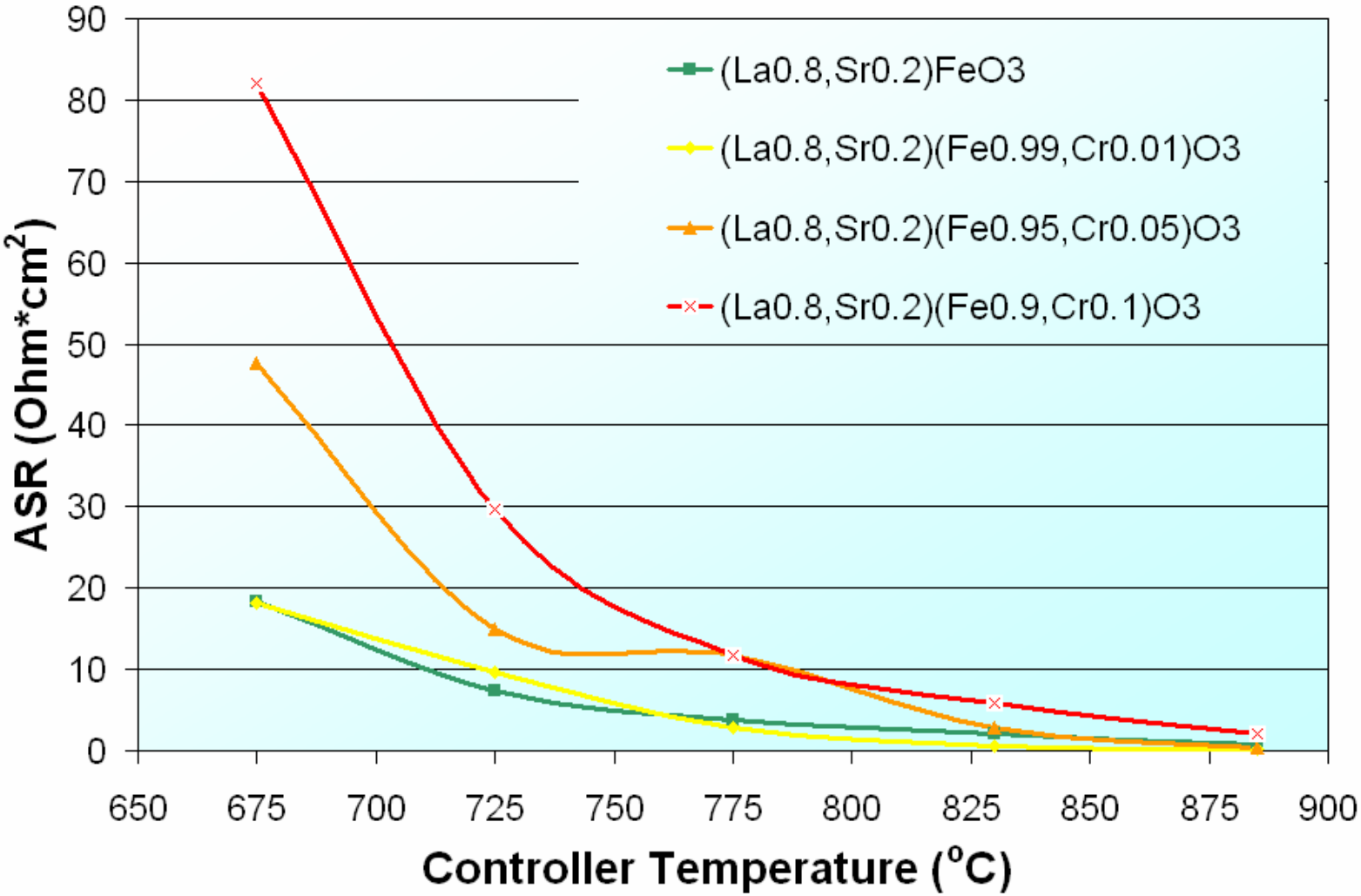
Chromium Substitution Objectives

- **Synthesize cathodes with Cr in structure**
- **Determine the effect of substituted Cr on cathode electrical resistance**

Cr Substitution Experimental Procedure

- **Materials prepared by glycine nitrate process**
  - Cr levels of 0,1, 5 and 10 mol% relative to B-site
- **Powders calcined, milled and made into an ink**
- **Ink placed on 8-YSZ tab and sintered**
- **AC impedance measured in this ½ cell configuration**
- **X-ray Diffraction**

Additions of Cr to LSF



Conclusions

- **While new alloys have reduced Cr poisoning, further development is still needed**
- **Cr_2O_3, $LaCrO_3$ and $MnCr_2O_4$ show mass loss that could result in "Cr poisoning"**
- **Chromium in the lattice of the cathode degrades performance**

Acknowledgements

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- **Program Manager: Wayne Surdoval**
- **Project Manager: Lane Wilson**