

# Chromium Vapor Sensor for Monitoring Solid Oxide Fuel Cell Systems

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## Chromium Poisoning

### Source of Chromium

- Oxidation of chromia scale
- Chromia formers used due to electronic conductivity of  $\text{Cr}_2\text{O}_3$  (relative to  $\text{Al}_2\text{O}_3$  and  $\text{SiO}_2$ )

### Chromium Deposition

- $\text{Cr}^{6+}$  reduced to  $\text{Cr}^{3+}$  (i.e.  $\text{Cr}_2\text{O}_3$ ) on cathode

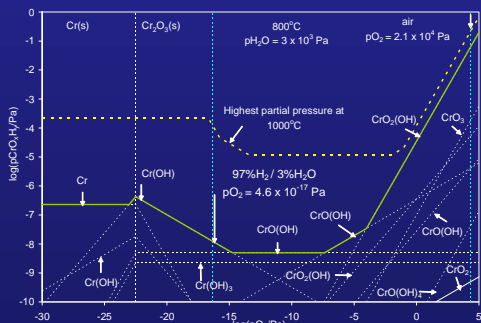
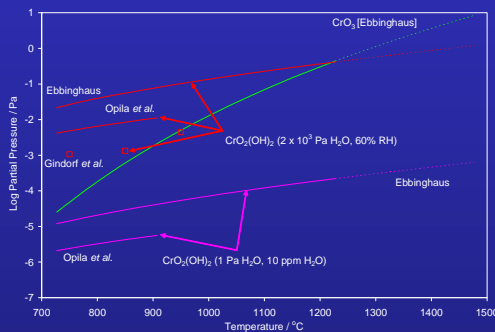
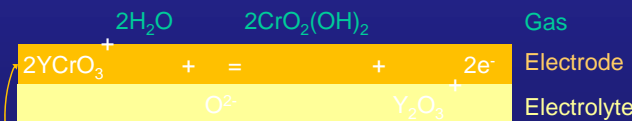
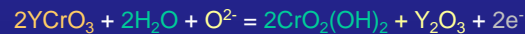
## Chemical Sensors

### Potentiometric

- Solid electrolyte based
- Thermodynamic – not kinetic
  - Stable
  - Microstructure independent

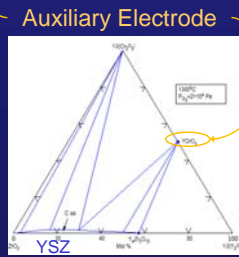
### Auxiliary Electrode

- Relate activity of target species to that of the mobile species
- Oxygen ion conductor for Cr
  - $2\text{Cr} + 3\text{O}^{2-} = \text{Cr}_2\text{O}_3 + 6\text{e}^-$
- Sodium ion conductor for Cr
  - $5\text{Cr} + 3\text{Na}_2\text{CrO}_4 = 6\text{Na}^+ + 4\text{Cr}_2\text{O}_3 + 6\text{e}^-$

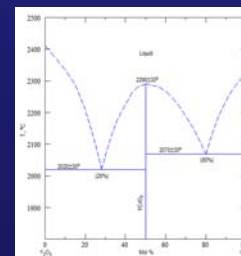


Partial pressures of chromium-containing species

B.B. Ebbinghaus, *Combust. Flame* 93[1-2] (1993) 119.  
C. Gindorf et al. *Sens. Research* 72[11] (2001) 528.  
E.J. Oplia et al. *JOM* 58[1] (2006) 22.



ACerS-NIST Phase Equilibrium Diagrams



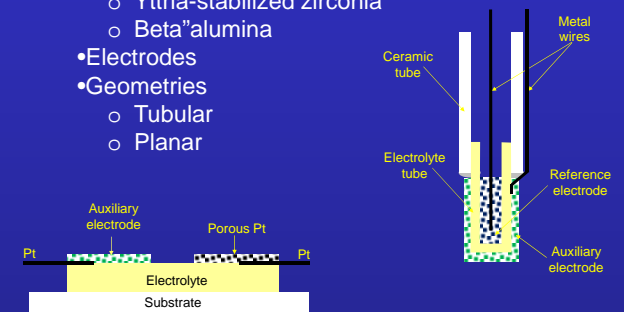
$\text{Y}_2\text{O}_3$  in YSZ

## Approach

### Phase I

#### Development of Chromium Sensor

- Solid electrolytes
  - Yttria-stabilized zirconia
  - Beta alumina
- Electrodes
  - Tubular
  - Planar
- Geometries
  - Tubular
  - Planar



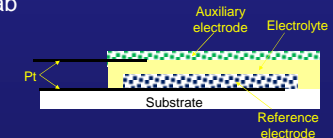
### Phase II

#### Evaluation in SOFC System

- Fuel Cell Energy

#### Integration with Chromium Capture System

- University of Connecticut
- Miniaturization using Thin Films
- Naval Research Lab



## Acknowledgment

Phase I selected for funding by the Department of Energy (DE-FOA-0001469)