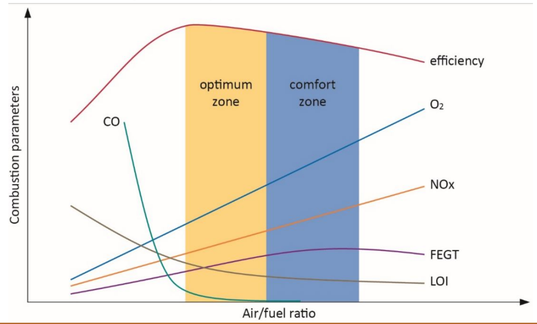
HIGH TEMPERATURE GAS SENSOR FOR COAL COMBUSTION SYSTEM

Wenyuan Li[1], Xingbo Liu[1], Eric Brosha[2], Cortney Kreller[2], Mukund Mukundan[2] Michael Carter[3], Bennett Meulendyk[3], Mel Finkdlay[3] Chad Hufnagel[4]

[1]West Virginia University; [2]Los Alamos National Laboratories; [3]KWJ Engineering; [4]Longview Power

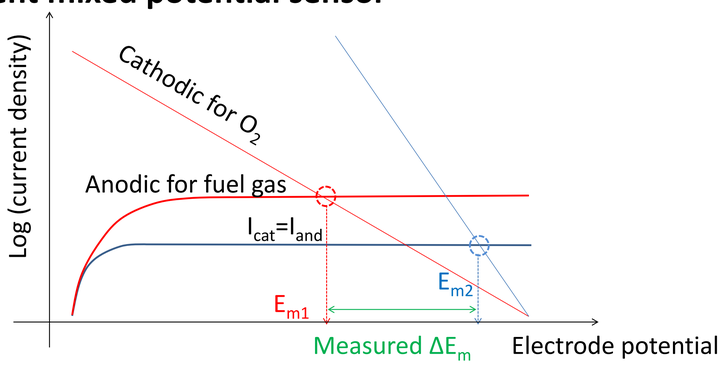
Objective

Develop a robust high temperature gas sensor capable of monitoring combustion in a coal-fired plant in real time to improve combustion performance based on refractory, reliable, catalytically materials. Integrate and test the basic components of the proposed sensor in a commercial, 700 MW power plant.

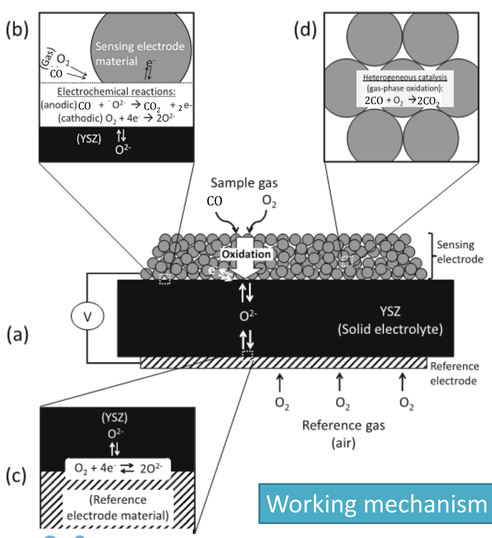


The variation of key combustion parameters with air/fuel ratio

Current mixed potential sensor



Source of potential difference: mixed potential



Cathodic half reaction:

$O_2 + 4e \rightarrow 2O^{2-}$

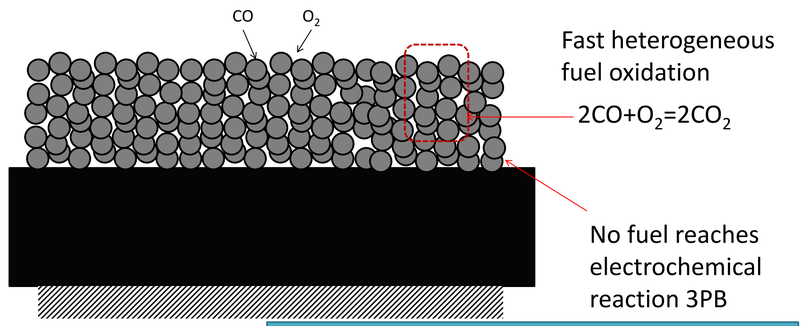
Anodic half reaction:

$CO + O^{2-} \rightarrow CO_2 + 2e$

Overall reaction at **EACH** electrode:

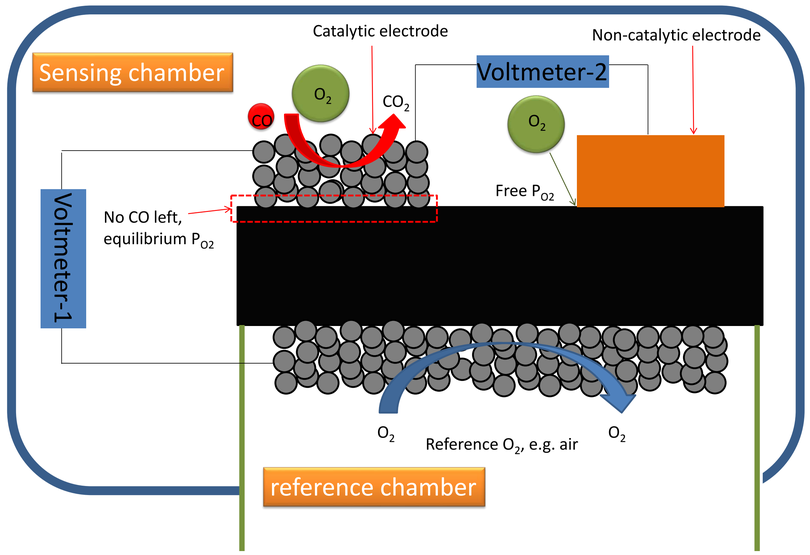
$2CO + O_2 \rightarrow 2CO_2$

Working mechanism of mixed potential sensor

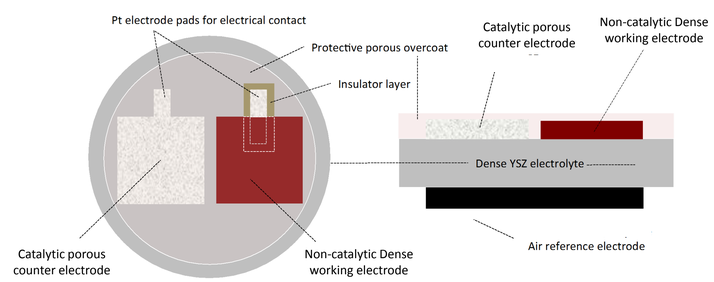


Working mechanism of mixed potential sensor

Our new sensor design: catalytic/non-catalytic sensor



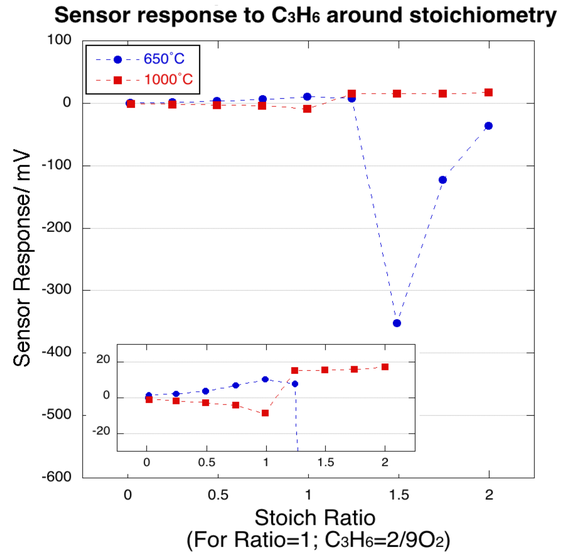
$$\Delta E_1 = \frac{RT}{nF}\ln\left(\frac{P_{O2,Free}}{P_{O2,Eq}}\right) \qquad \Delta E_2 = \frac{RT}{nF}\ln\left(\frac{P_{O2,Eq}}{P_{O2,ref}}\right)$$



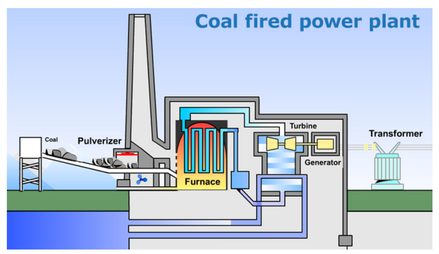
Schematic of the proposed high temperature gas sensor

- Mixed potential sensors
- T_{op} < 600 °C
- High sensitivity to CO/HCs/NOx
- High durability
- Dense electrodes/Porous electrolyte

- Oxygen (Free vs Equilibrium)
- T_{op} up to 1500 °C
- Higher sensitivity as T↑ and P_{O2}↓
- High durability
- One dense and one porous electrode



A significant signal (~10mV) obtained from previous experiment on (sensing electrode for C_3H_6 when measured at high temperature (1000°C) at near stoichiometric ratio.



Longview 700 MW coal-fired power plant

I.D.	Task	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
1.0	Project Management	■	■	■	■	■	■	■	■
2.0	Sensor Development	■	■	■		■	■		
3.0	Sensor Packaging		■	■			■		
4.0	Lab-scale Sensor Testing		■	■			■	■	
5.0	Post-mortem Characterization			■	■			■	■
6.0	Electrochemical Mechanisms Investigation	■	■	■	■	■	■		
7.0	Sensor Testing in Utility Boiler							■	■

Advantages of Proposed High Temperature Gas Sensor

- Utilized the advantages of low-temp mixed potential sensors, but overcome the issued related to high-temp applications
- Simple sensor design, Voltage reading proportional to log concentration of reducing gases
- Excellent high temperature stability. Same materials used in high temp SOFC and oxygen sensor applications

1. Ionics (2014) 20:901–925
2. Advanced sensors and smart controls for coal-fired power plant, IEA CLEAN COAL CENTRE