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CO Sensors for Reformate Powered Fuel Cells

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Objectives

- Reformate gas powered fuel cell systems require sensors for carbon monoxide level monitoring and feedback control
  - A high temperature sensor is required for measurement of 0.1 to 2% CO in reformate gas for fuel processor control
  - A low temperature sensor for measuring 10-100 ppm range concentrations for stack poisoning control

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Approach

- Two different electrochemical sensor types are being investigated for high and low temperature CO sensing
  - An oxide solid electrolyte device is being developed for the high temperature application
    - Yttria stabilized zirconia oxygen ion conducting electrolyte
    - Strontium yttrium zirconium perovskite proton conducting electrolyte
  - Low temperature amperometric device based on CO inhibition of hydrogen oxidation kinetics
    - Perfluorosulfonic acid polymer electrolyte
    - Inorganic acid electrolyte

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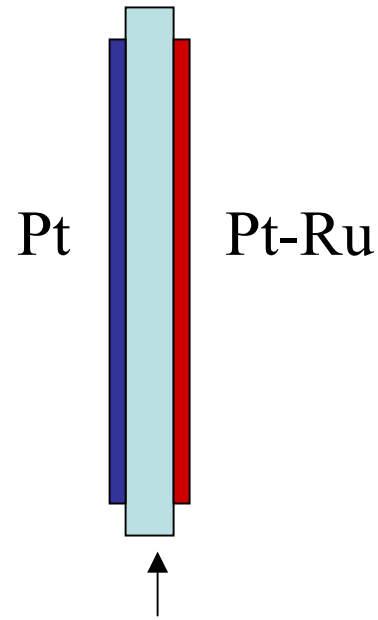
Approach

Low temperature Amperometric Sensor

- Use Nafion as the proton conducting membrane
- Use Pt or Ru electrode as working electrode
  - is sensitive to CO poisoning
- Use Pt-Ru electrode as a counter electrode
  - more tolerant to the presence of CO



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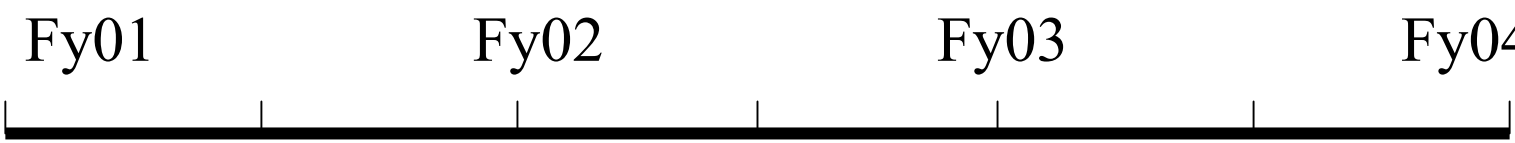
Project Timeline



Project begins

Low temp CO sensor prototype developed
Sense 100-1000ppm CO in H2

High temp CO sensors first prototypes made
Sense 1-500ppm CO in Room Air

Oxide proton conductor thin film technology developed

Ellucidated the working principle of these low temperature sensors

Improved Low Temperature sensor
Works at Room Temperature
Stable response to 10-200ppm CO in H2

Oxide based amperometric sensors do not have sensitivity to CO and Oxide based mixed-potential sensors do not operate stabily in the presence of H2

Continue work on the low temperature sensors to optimize sensor response, stability and response time

Project ends

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Accomplishments

- Effect of CO on typical fuel cell electrode loadings
  - Working Electrode
    - Pt/C/Nafion : 0.22mg/cm^2 of Pt or
    - Ru/C/Nafion : 0.12mg/cm^2 of Ru
  - Reference Electrode
    - Pt/Ru/C/Nafion : 0.25mg/cm^2 of Pt/Ru(50/50)alloy
  - Electrolyte
    - Nafion 1135

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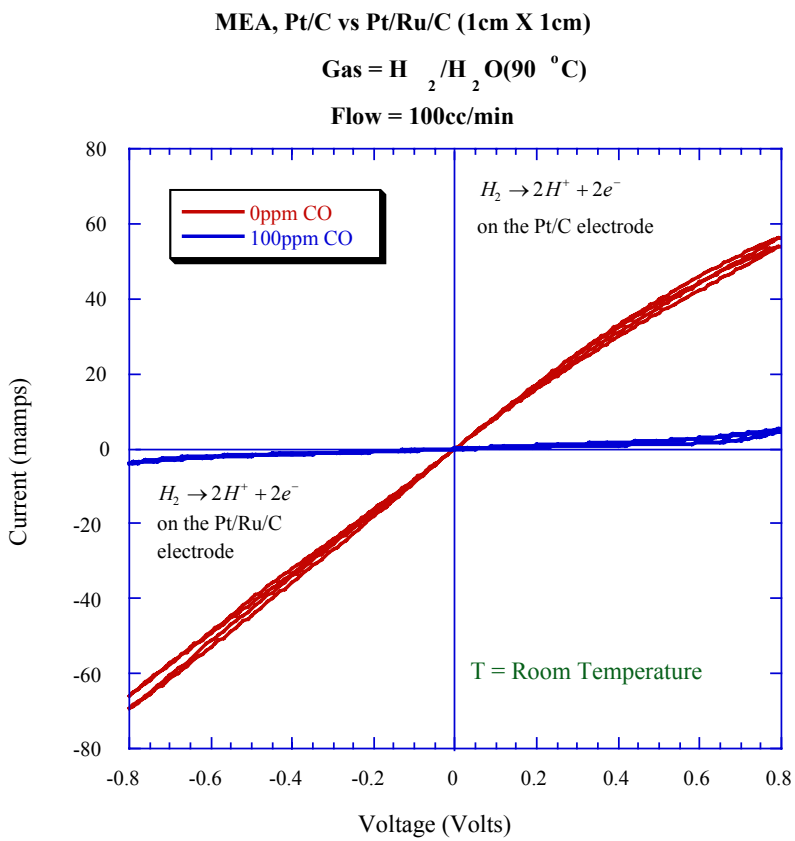
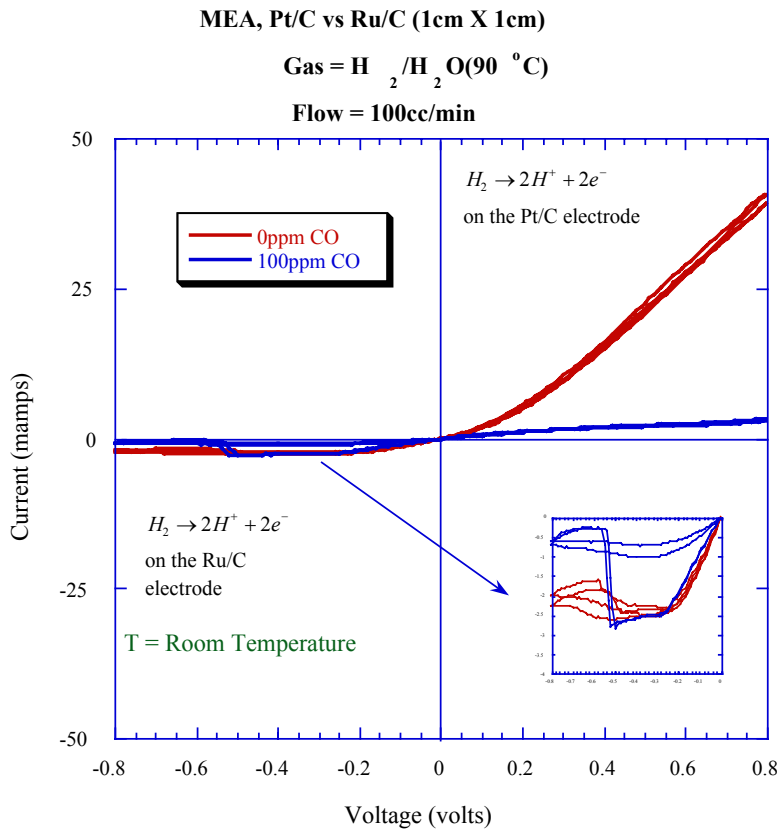
Accomplishments

- Both the Pt/C and the Pt/Ru/C electrodes are good at hydrogen oxidation and both of them get poisoned by the CO
- The CO poisoning is not easily reversible
  - Recovery takes hours without air bleeding



Accomplishments

- While the Pt/C electrode is good at hydrogen oxidation the Ru/C electrode is not very efficient at H_2 oxidation
- Both the electrodes get poisoned by the CO, the Ru/C electrode to a lesser extent
- The CO from the Ru/C electrode can be easily stripped at voltages <-0.5V (see inset)
- The CO poisoning is not easily reversible on the Pt/C electrode
  - Recovery takes hours without air bleeding



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Accomplishments

- Effect of CO on sensor response at high catalyst loadings
  - Working Electrode
    - Pt/Nafion : ≈10mg/cm^2 of Pt or
    - Ru/Nafion : ≈10mg/cm^2 of Ru
  - Reference Electrode
    - Pt/Ru/Nafion : ≈10mg/cm^2 of Pt/Ru(50/50)alloy
  - Electrolyte
    - Nafion 117

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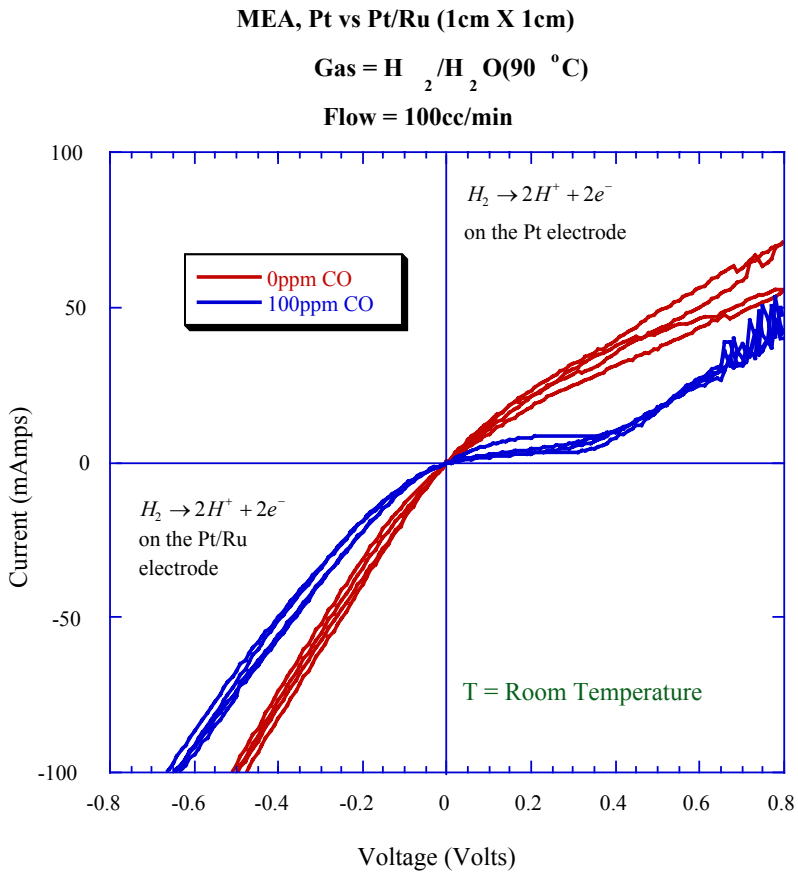
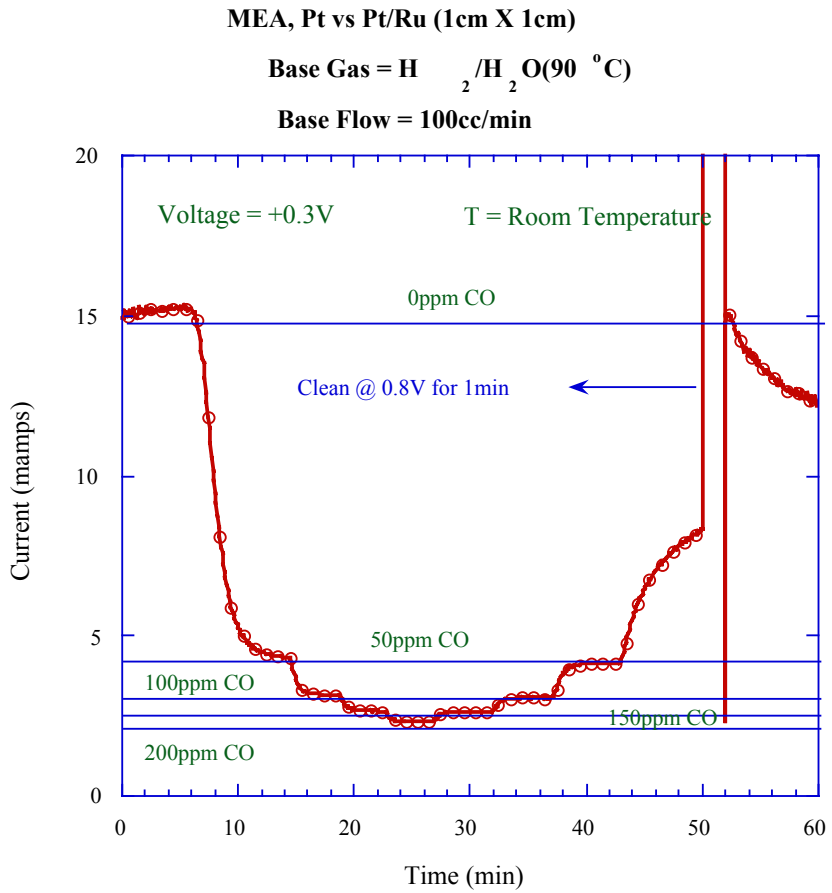
Accomplishments

- Both the Pt and Pt/Ru alloy electrodes are good for H_2 oxidation
- There is very little effect of CO on the Pt/Ru alloy electrode.
  - This electrode could serve as a pseudo-reference electrode
- The Pt electrode gets poisoned by the CO which can easily be cleaned at voltages > 0.4V



Accomplishments

- The extent of poisoning on the Pt electrode can be used to give a useful sensor response
- The current at 0.3V decreases from 15mamps to <5mamps when the CO content in the H_2 stream is increased from 0 to 50ppm.
- The final CO can be cleaned by applying a 0.8V potential for approx. one minute



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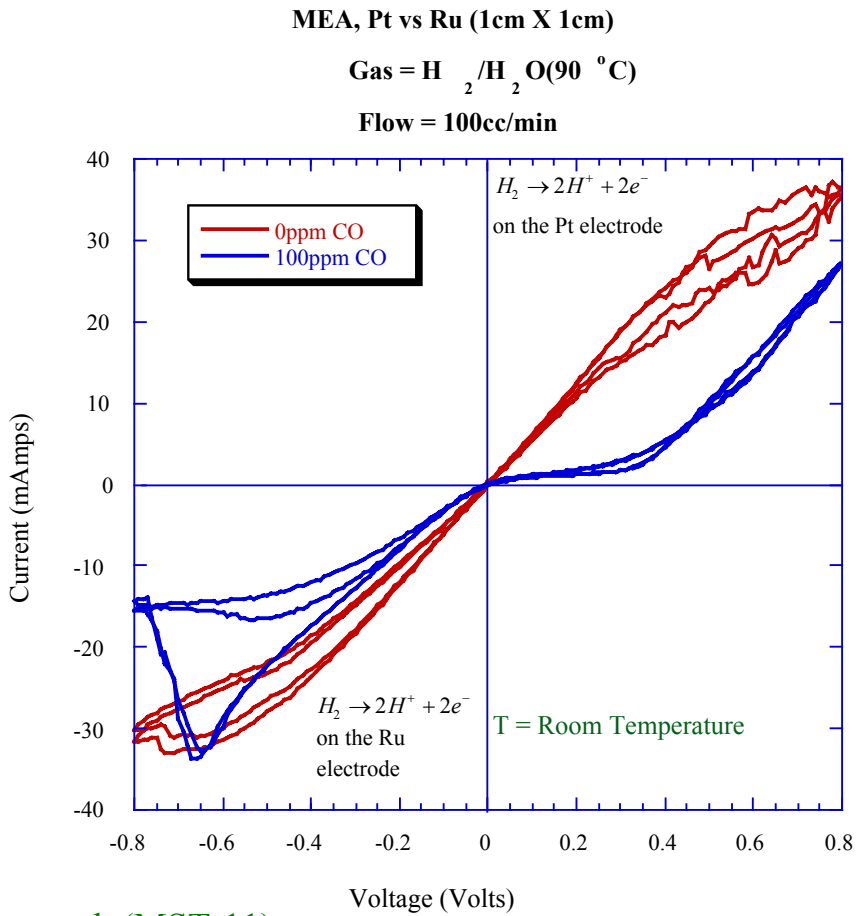
Accomplishments

- Both the Pt and Ru electrodes are good for H_2 oxidation
- The Pt electrode gets poisoned by the CO which can easily be cleaned at voltages > 0.4V
- The Ru electrode also gets poisoned by the CO and can be cleaned at voltages < -0.6V
  - The clean up on this electrode appears to be slower than that of the Pt/Ru alloy electrode



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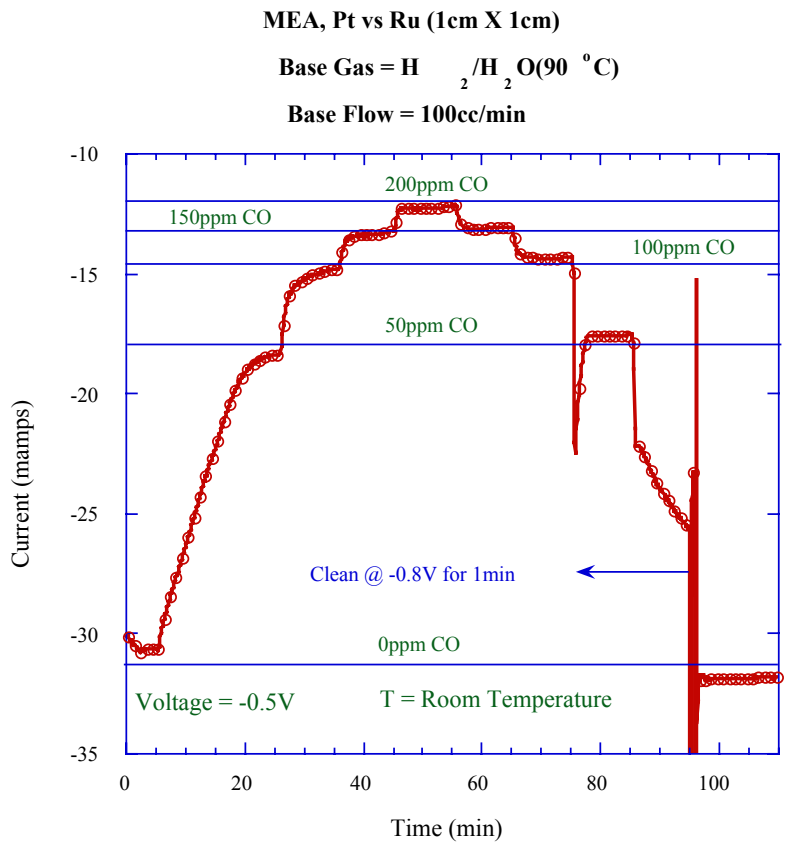
Accomplishments

- The extent of poisoning on the Ru electrode can be used to give a useful sensor response
- The current at -0.5V decreases from -30mamps to -18mamps when the CO content in the H_2 stream is increased from 0 to 50ppm.
- The final CO can be cleaned by applying a -0.8V potential for approx. one minute



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Future Plans

- Study the stability of these sensors at room temperature
- Increase the operating temperature of these sensors to 80-90^{o}C
- Study water management issues in these sensors and stabilize the sensor response at elevated temperatures
- Optimize electrodes and electrolyte to get maximum sensitivity to CO

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