

High-Temperature Gas Sensing

Combustion of fossil fuels currently generates most of the nation's energy, and 2008 forecasts by the Energy Information Agency predict this will continue to be the case for at least the next two decades. In addition to generating the greenhouse gas CO₂, combustion of any carbonaceous fuel can generate pollutants such as oxides of nitrogen (NO_x, NO and NO₂), carbon monoxide (CO), and residual hydrocarbons. Further, combustion of coal and diesel has the prospect of generating sulfur dioxide (SO₂), which will form acid rain when mixed with the water and oxygen naturally found in the Earth's atmosphere.

We have demonstrated success in detecting NO_x, SO₂, and NH₃ at high temperature (Figures 1-3) and are currently refining these techniques while simultaneously expanding our suite of technologies to encompass high-temperature CO₂ measurement and feedstock characterization.

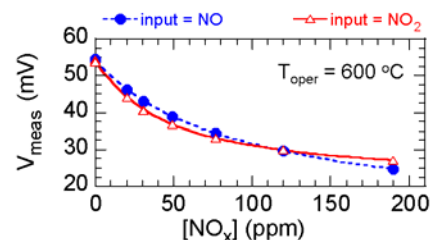


Fig. 1. "Total NO_x" sensing behavior. NO and NO₂ yield nearly identical responses, eliminating the need for conversion to a single species before measurement.

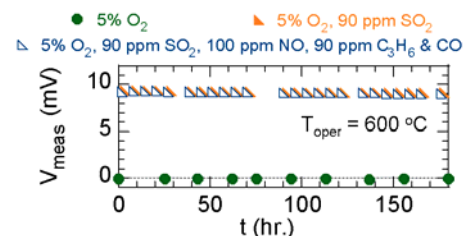


Fig. 2. Selective and stable SO₂ detection. The output if [SO₂] = 0 is ~0 mV; the output if [SO₂] = 90 ppm is ~10 mV, irrespective of the presence/absence of the interferents NO, C₃H₆, and CO. Operation without calibration or adjustment over approximately 1 week is shown.

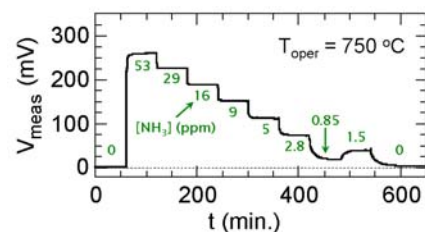


Fig. 3. Detection of single-digit "parts-per-million levels" of NH₃ at high temperature.

Advancing the
Forefront of
Combustion
Measurement
and Control

Purpose: Develop techniques for combustion exhaust measurements and fuel characterization. The emphasis is on techniques suitable for harsh, aggressive environments and high temperatures.

Sponsor: Department of Energy Fossil Energy Program.

Features:

- Fully automated high-temperature test stands for sensing element characterization.
- Mixtures of up to six gases can be used in testing.

Complementary

ORNL Facilities:

- National Transportation Research Center.
- High Temperature Materials Laboratory.

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Capabilities

Our current capabilities include sensing element fabrication and characterization. Fabrication facilities include ceramics processing equipment for tape casting, lamination, and sintering and equipment for manufacture and screen printing of dispersions (Figure 4). Characterization facilities include fully automated high-temperature test stands and equipment for electrochemical investigations.

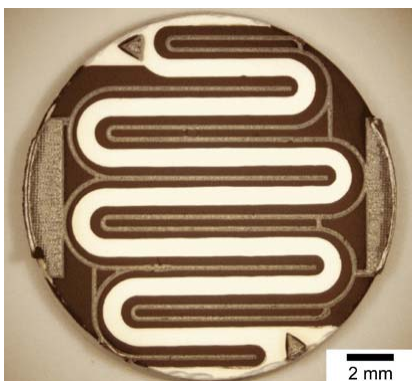


Fig.4. High-temperature sensing element.

Additional Nearby Facilities

- The High Temperature Materials Laboratory (<http://www.ms.ornl.gov/htmlhome/>) is a DOE User Facility dedicated to solving materials problems that limit the efficiency and reliability of systems for power generation and energy conversion, distribution, and use.
- The National Transportation Research Center (<http://www.ntrc.gov/about.html>), a collaborative venture of ORNL and the University of Tennessee, addresses issues related to expanding and maintaining transportation systems that move people and goods safely, efficiently, and reliably.

Selected Publications

- D. L. West, F. C. Montgomery, and T. R. Armstrong, "Total NO_x sensing elements with compositionally identical oxide electrodes," *Journal of the Electrochemical Society*, **153**(2), H23–8, 2006.
- D. L. West, F. C. Montgomery, and T. R. Armstrong, "NO-selective NO_x sensing elements for combustion exhausts," *Sensors and Actuators B*, **111–112**, 84–90, 2005.