Chemical Sensing of Explosives

Otto J. Gregory, PhD

URI Sensors and Surface Technology Partnership
Chemical Engineering Department
University of Rhode Island
Kingston, RI 02881

gregory@egr.uri.edu

Vapor Detection…… Can we compete with a dog's nose?

- ✓ *sensitive…..low detection limits*
- ✓ *fast, accurate……..*
- ✓ *real time processing…..*
- ✓ *portable……..*
- ✓ *low volatility explosives…..*
- ✓ *plume tracking…directional*

Electronic trace detection (ETD) system:

continuous monitoring/screening…24/7
sensitivity…..low detection limits
selectivity….mitigate false positives
expandable to new threat molecules

Our answer: *an orthogonal sensor for vapor detection*

ADSA14: Trace, Chemical and Stand-off Detection

Summary

Orthogonal sensor can detect explosives in the vapor phase at trace levels: this ETD system is a continuous, passive system with built-in redundancies; metal oxide catalyst is simultaneously interrogated using thermodynamic and conductometric platforms

How would TSA benefit from our technology?

Increased detection capability …can detect both peroxide and nitrogen based explosives. Reduction in rates of false positives. Expanded threat library. Enhanced selectivity and sensitivity…….

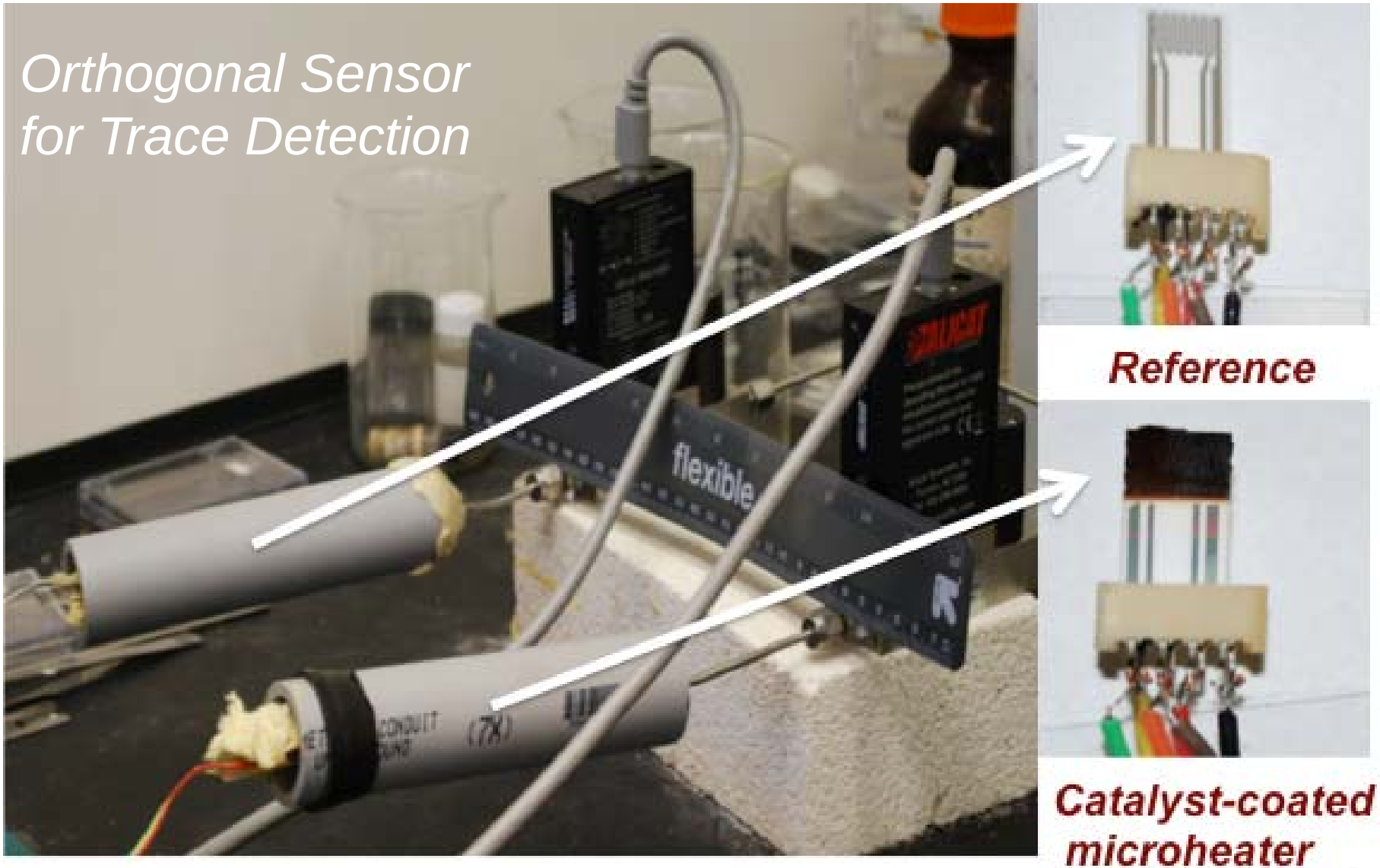
So what?

Technology will lead to better screening/monitoring for explosives

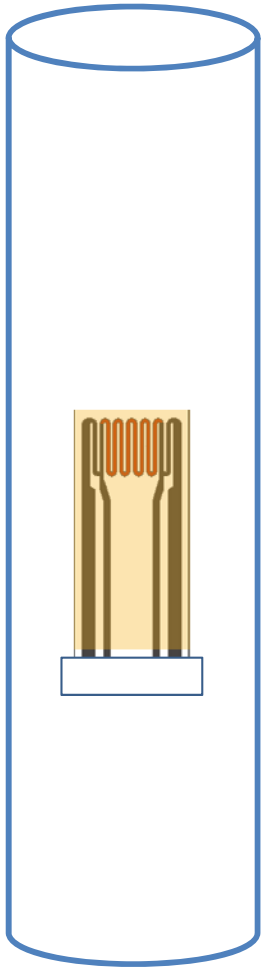
Who cares?

TSA and those trying to protect the traveling public; port security and those screening cargo for explosives

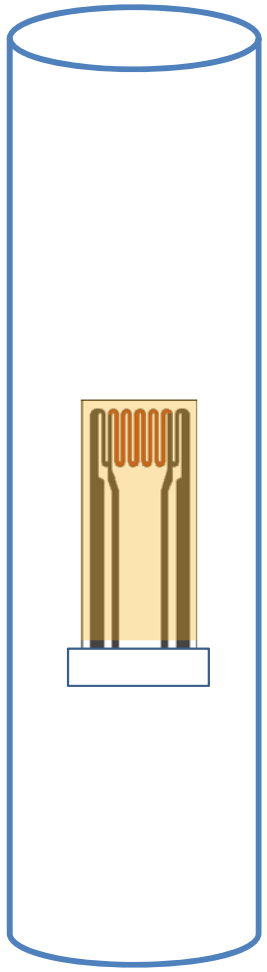
ADSA14: Trace, Chemical and Stand-off Detection



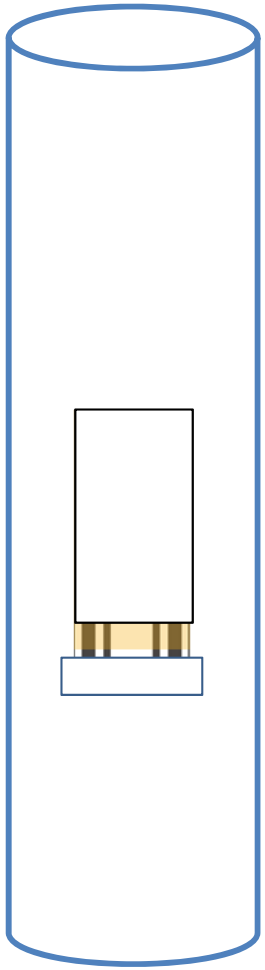
ADSA14: Trace, Chemical and Stand-off Detection



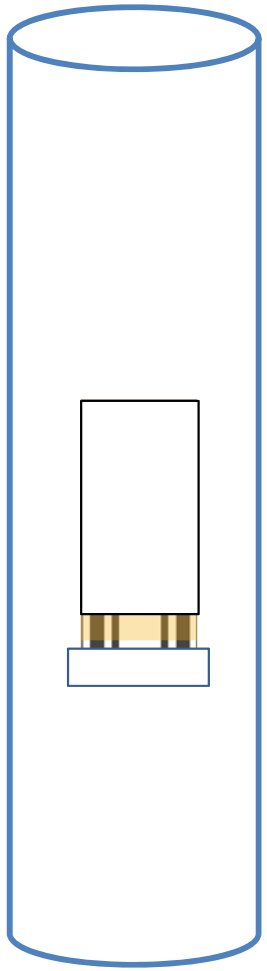
Two microheaters with identical electrical properties are thermally isolated in separate chambers.



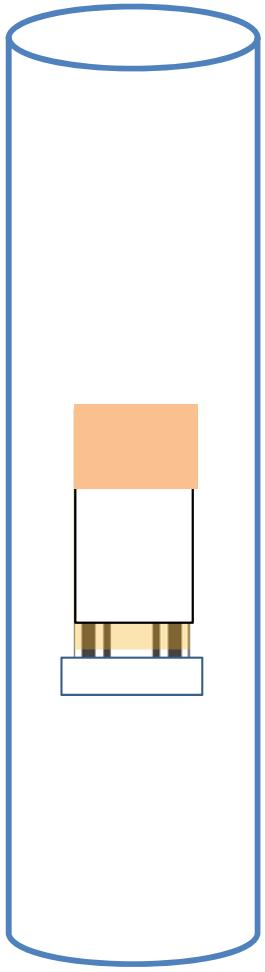
ADSA14: Trace, Chemical and Stand-off Detection



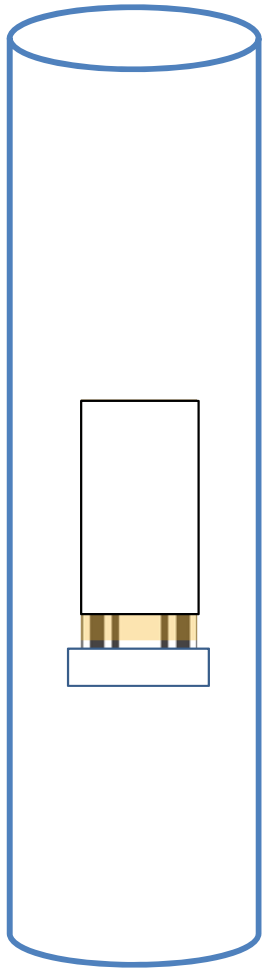
Both heaters are coated with an alumina dielectric.



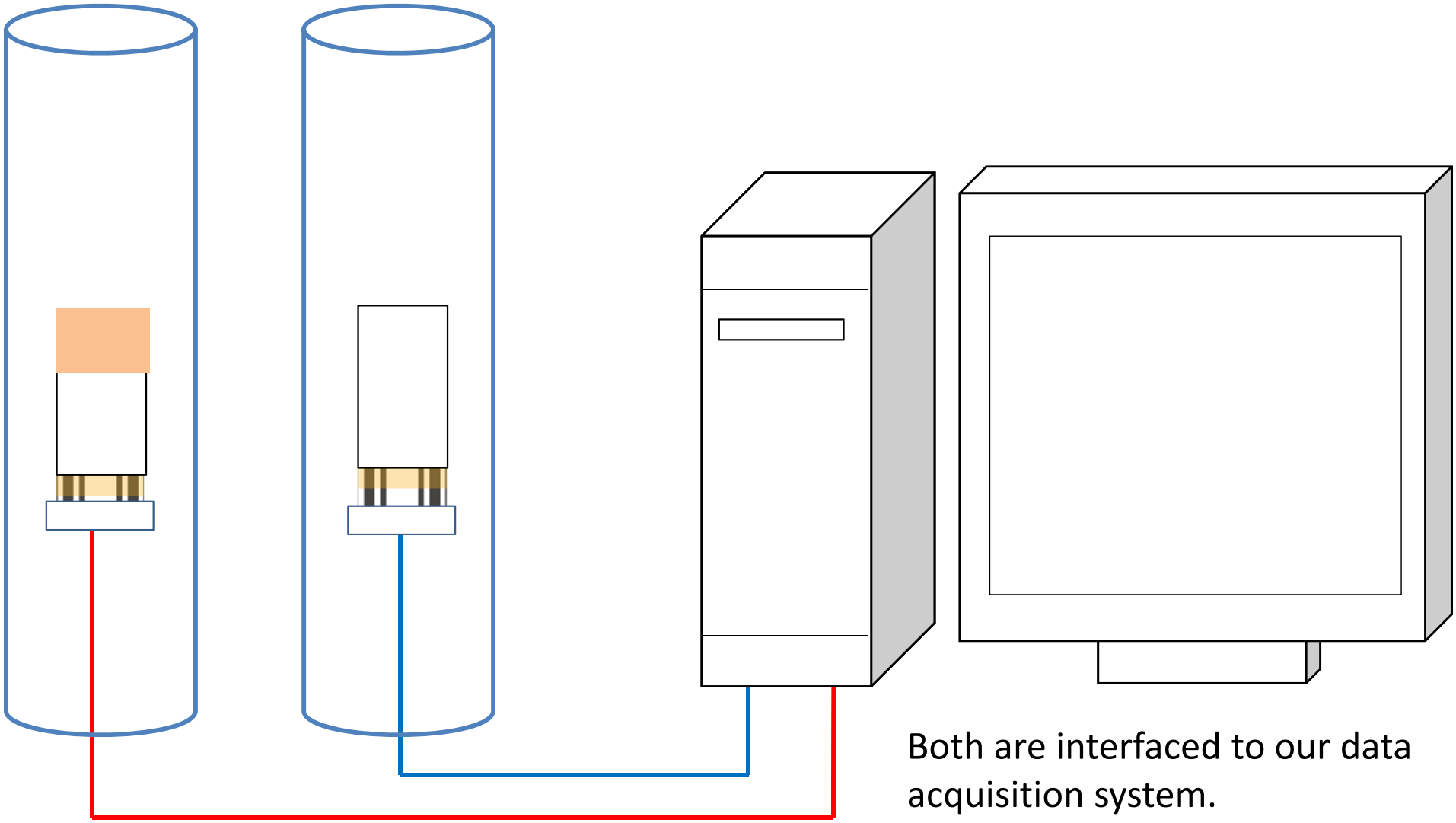
ADSA14: Trace, Chemical and Stand-off Detection



Only one is coated with a metal oxide catalyst.



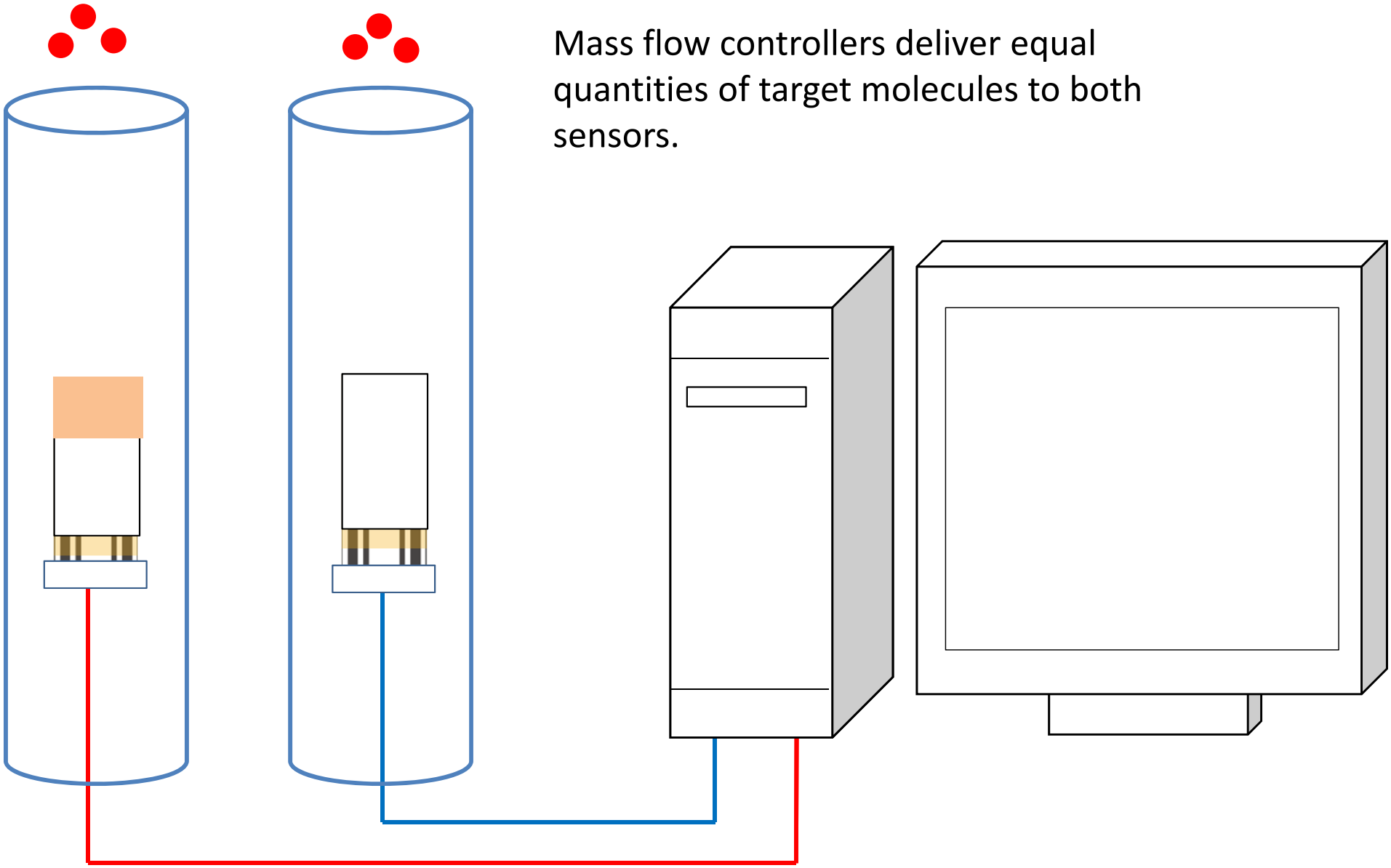
ADSA14: Trace, Chemical and Stand-off Detection



Both are interfaced to our data acquisition system.

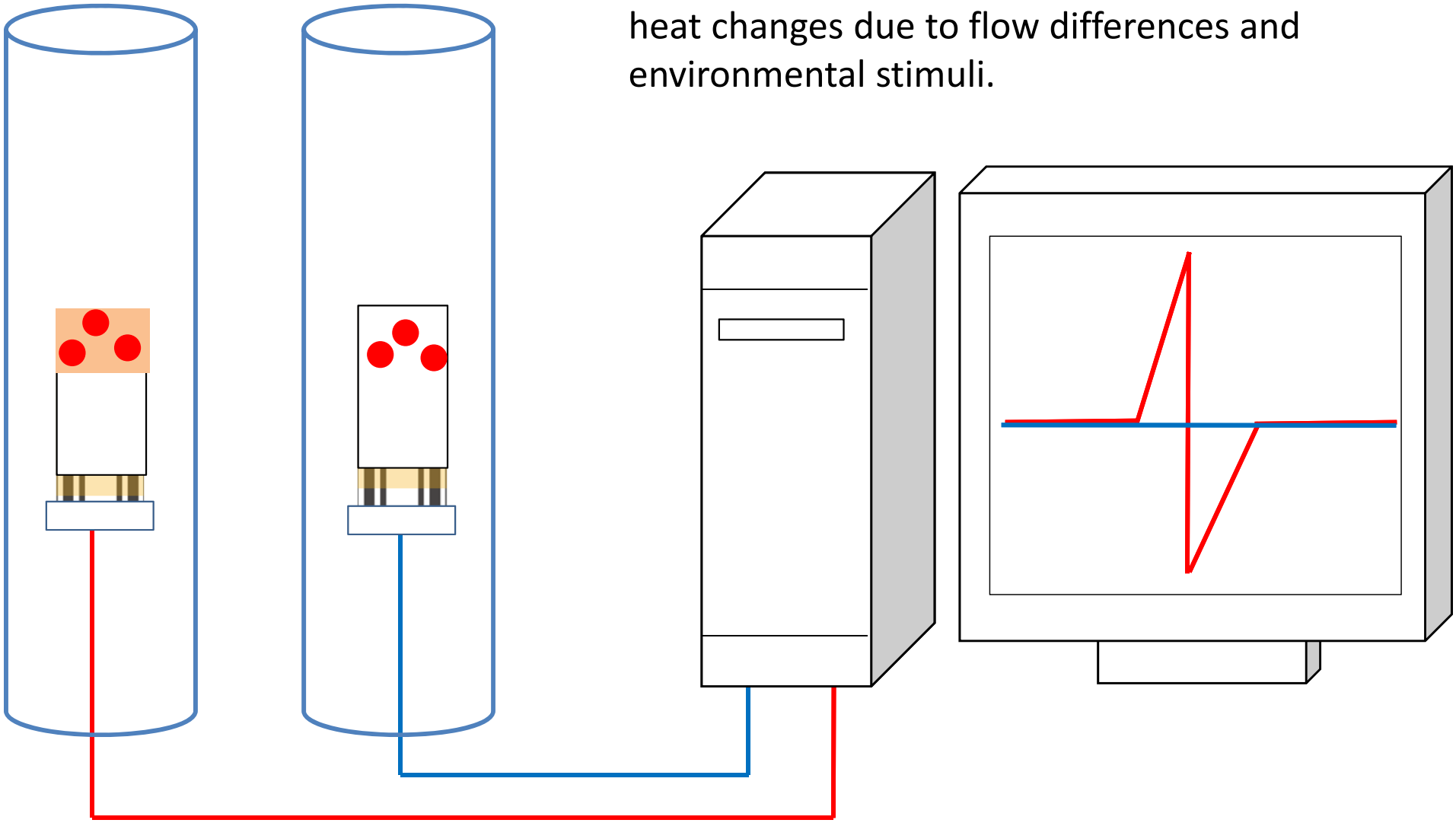
ADSA14: Trace, Chemical and Stand-off Detection

Mass flow controllers deliver equal quantities of target molecules to both sensors.



ADSA14: Trace, Chemical and Stand-off Detection

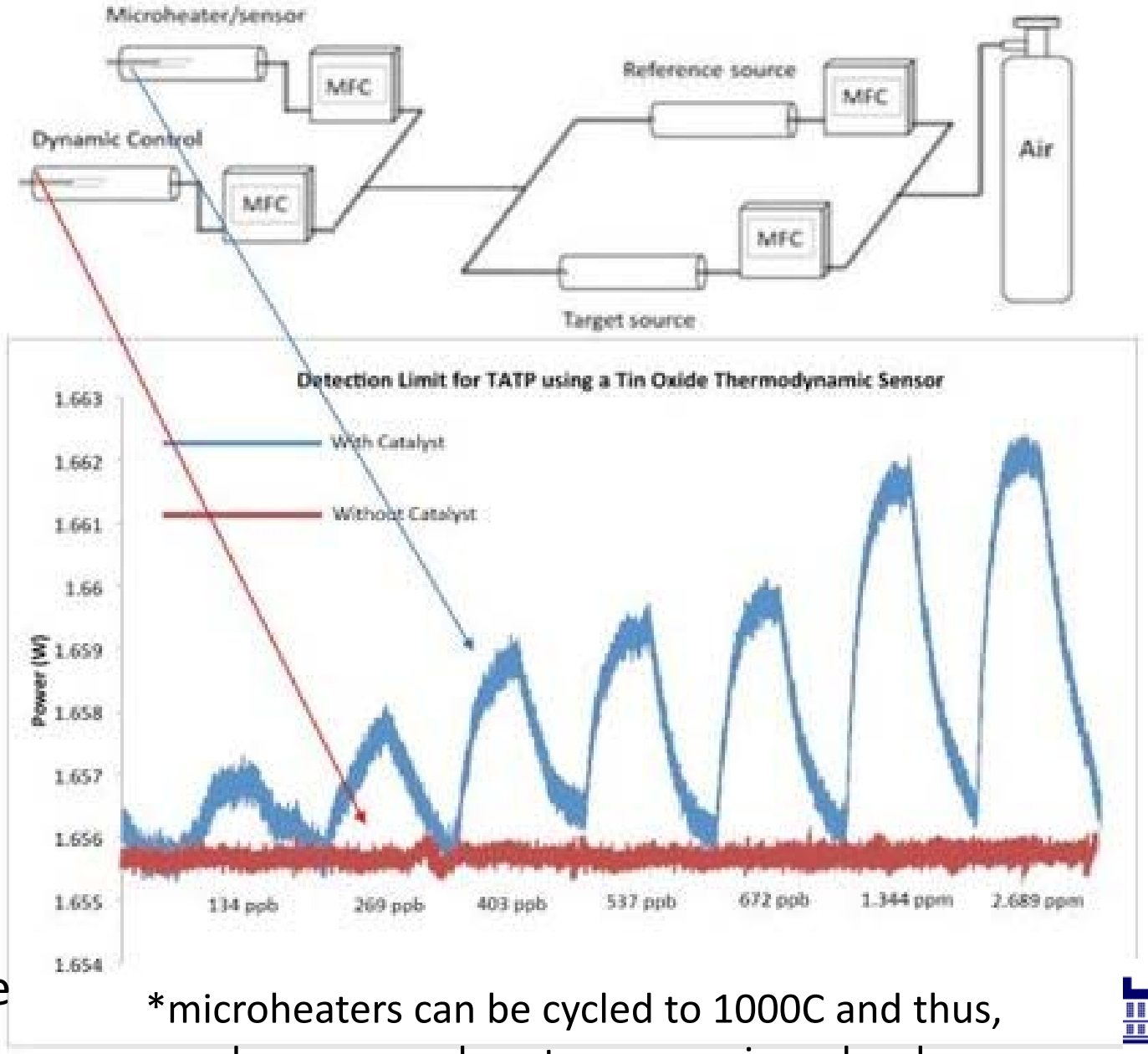
Only the catalyst coated microheater will respond to the analyte, and the bare sensor will record heat changes due to flow differences and environmental stimuli.



ADSA14: Trace, Chemical and Stand-off Detection

Catalyst-coated microheater senses sensible heat effects plus the heat effect associated with with catalyst-analyte interactions. By subtracting the ref. signal, extraneous heat effects are cancelled out; response is due to catalytic activity only.

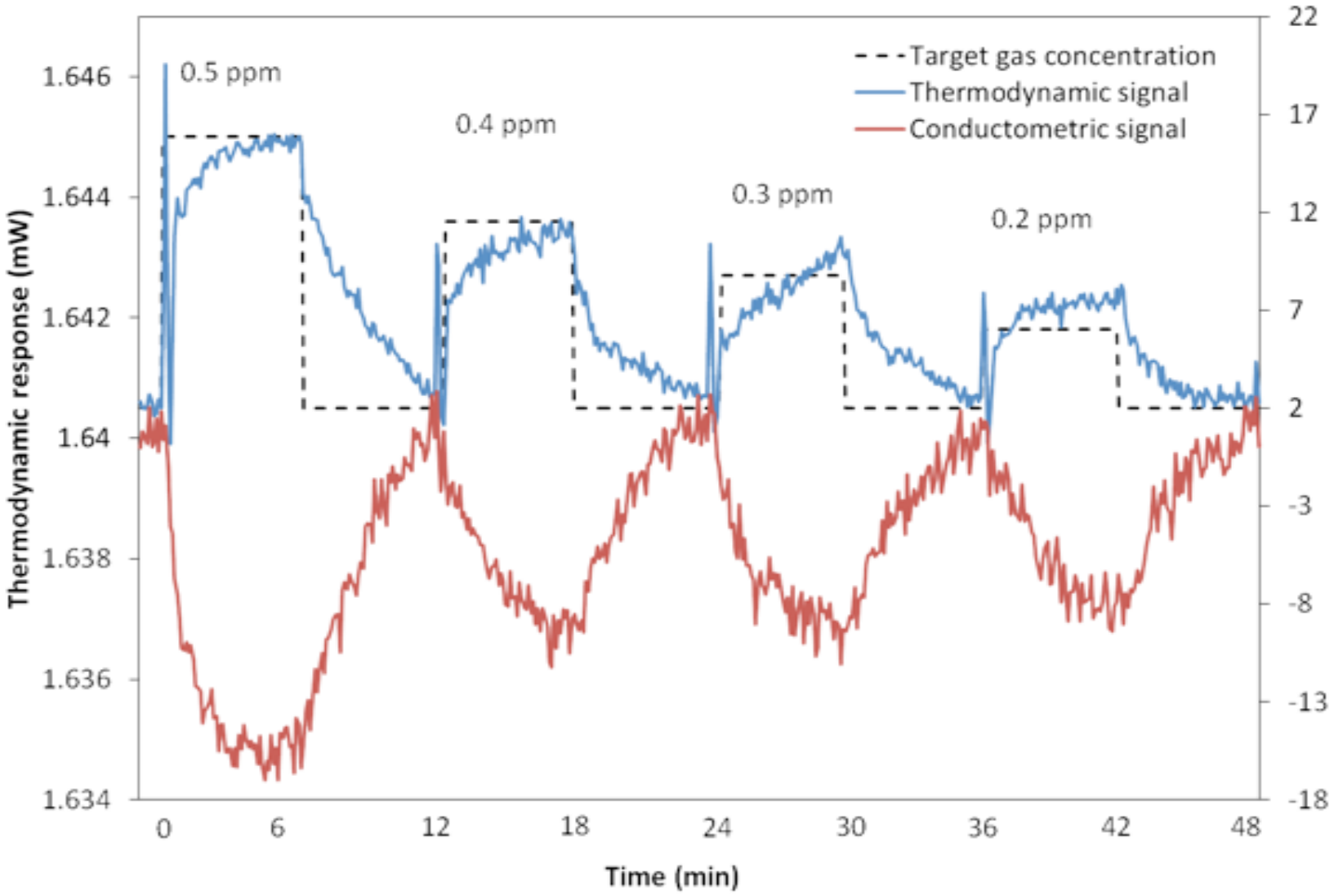
*a small air pump is used to draw the incoming air over the sensor



*microheaters can be cycled to 1000C and thus, can decompose almost any organic molecule

UNIVERSITY OF Rhode Island

Orthogonal response to 2, 6-DNT at 410 ℃ (SnO catalyst)



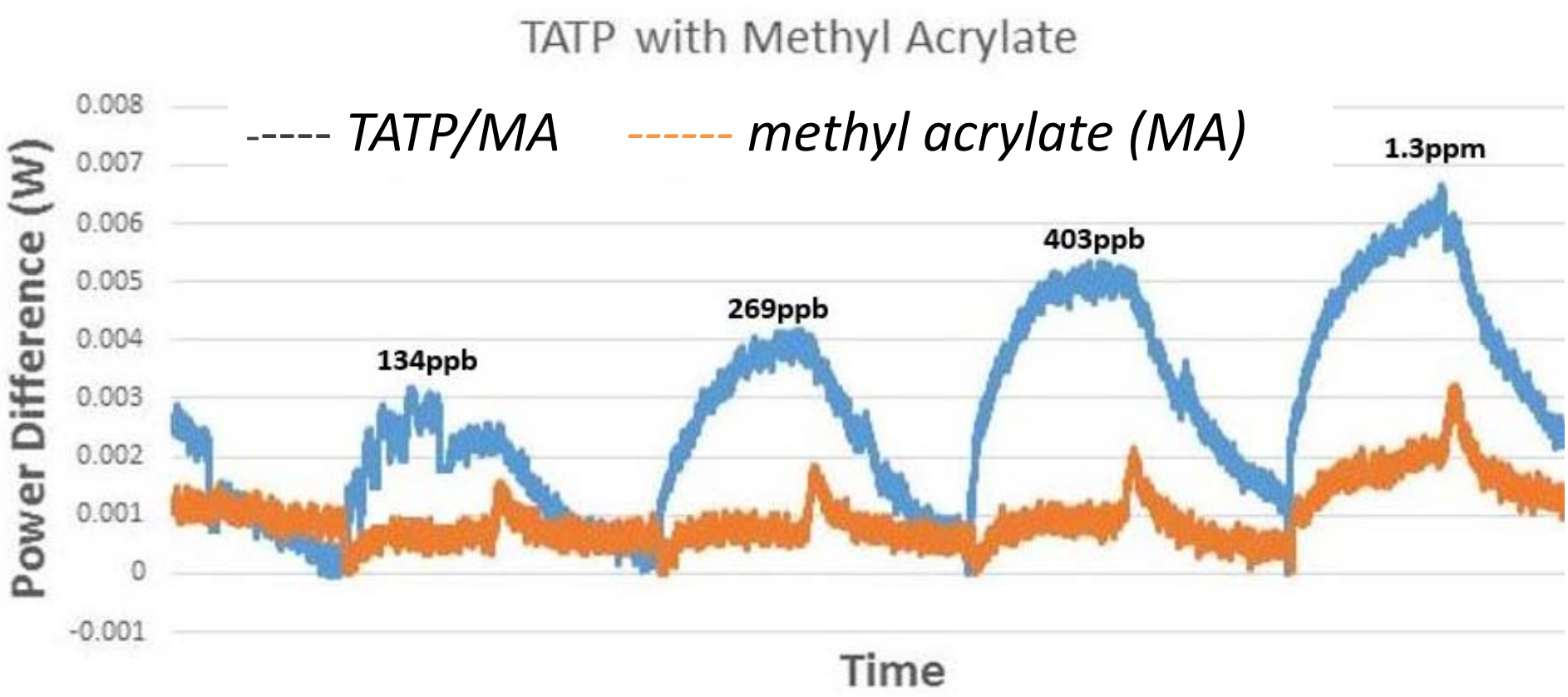
Center for Sensors and Instrumentation Research

May 11, 2016

UNIVERSITY OF Rhode Island

Catalyst selectivity: Interferents

Interferent molecules such as methyl acrylate (MA) could mask sensor response and compromise reliable cargo screening



Summary

Heat effect due to catalytic decomposition of explosive is measured by subtracting the reference signal from the catalyst-coated sensor signal; extraneous heat effects cancel out and sensor response is due to catalytic activity only…… can detect TATP, AN and 2-6 DNT at the "single" ppb level

Using orthogonal sensor modalities, the metal oxide catalyst is simultaneously interrogated using thermodynamic and conductometric platforms ……this will mitigate false positives and false negatives

*Our sensor technology can compete with a dog's nose***

Acknowledgements

These materials are based upon work supported by the U.S. Department of Homeland Security, Science and Technology Directorate, Office of University Programs, under Grant Award 2013-ST-061-ED0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security.

Center for Sensors and Instrumentation Research

UNIVERSITY OF Rhode Island