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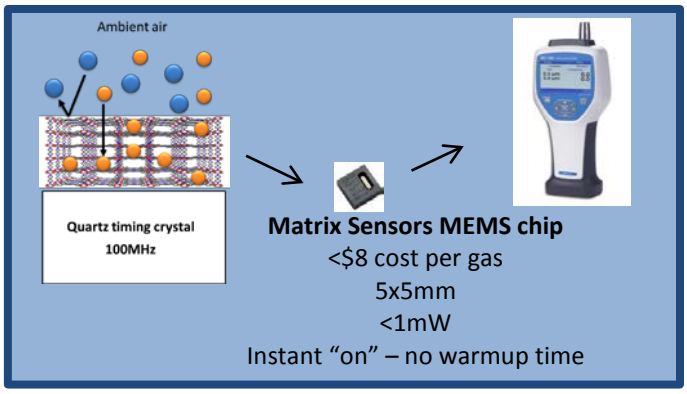
DHS Science and Technology Directorate

Field Detection and Analysis for Fire Gases and Particulates: Metal Organic Frameworks

Handheld Detector for Use in Post Fire Environments:

Fire investigators and other first responders involved in a post-fire investigation require the ability to detect, monitor and analyze potential fire hazards that gases and particulates pose to the health of the first responders at the scene. Current detection systems have limited capabilities, or are cumbersome and expensive.

The Department of Homeland Security, along with Matrix Sensors, Inc. – a Micro-Electro-Mechanical Systems or MEMS sensor company whose mission is to enable chemical sensing for next generation mobile devices – initiated a Small Business Innovation Research (SBIR) Project to develop a portable, rugged handheld multi-gas sensor.



Far left is a graphic of an individual sensor device; Middle is a packaged chip with specifications; Far right is a final potential configuration

The detector consists of a quartz crystal microbalance (QCM) mass transducer that is coated with carefully engineered sensing materials (metal-organic frameworks or MOFs).

MOF coatings for up to 12 gases will be identified, grown, tested, and if appropriately selective, will be applied to QCMs. The handheld detector will Include a mercury sensor and particulate counter, as well as gas sensors. Algorithms will be developed to report gas concentration, or alarm states based on sensor output. Prototype subsystems (power, gas sampling, microcomputer, user interface, etc.) will also be developed, culminating in the fabrication of three functional prototypes.

This project is being executed in two phases:

Phase I:

During Phase I, research was conducted to demonstrate the feasibility of using MOFs to detect multiple gases. To this end, eight different MOF thin films were grown and characterized. Sensor sensitivity was demonstrated for four different MOF systems for Hydrogen sulfide, Carbon dioxide, Methane and Ammonia. Phase I ended in February 2015.

Phase II:

During Phase II, portable, rugged handheld multi-gas prototype sensors will be developed. These sensor chips boast extraordinary sensitivity to changes in mass (e.g., 50 femtograms). Chips will be coated with materials that exhibit highly selective uptake of the target gases. When the device is exposed to a gas molecule that binds to the coating material, the resulting mass change will be detected by the mass sensor. The chemical kinetics of the coatings will be engineered to selectively adsorb and desorb the target gases with sub-10 second response times.

A commercial particle counter will be integrated into the detector. The mass sensors are small, thin (5x5x1mm) and light (less than 1 gram) with readout electronics that can fit on a standard pc board that is 3 in x 3 in x 0.2 in, while consuming 700 mW of power allowing for 17 hours of continuous operation. At the end of Phase II (August 2017), three prototype detectors will be delivered for operational testing.

Homeland Security
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To learn more about Fire Gases SBIR Projects, contact SandTFRG@hq.dhs.gov.

2017-01-26