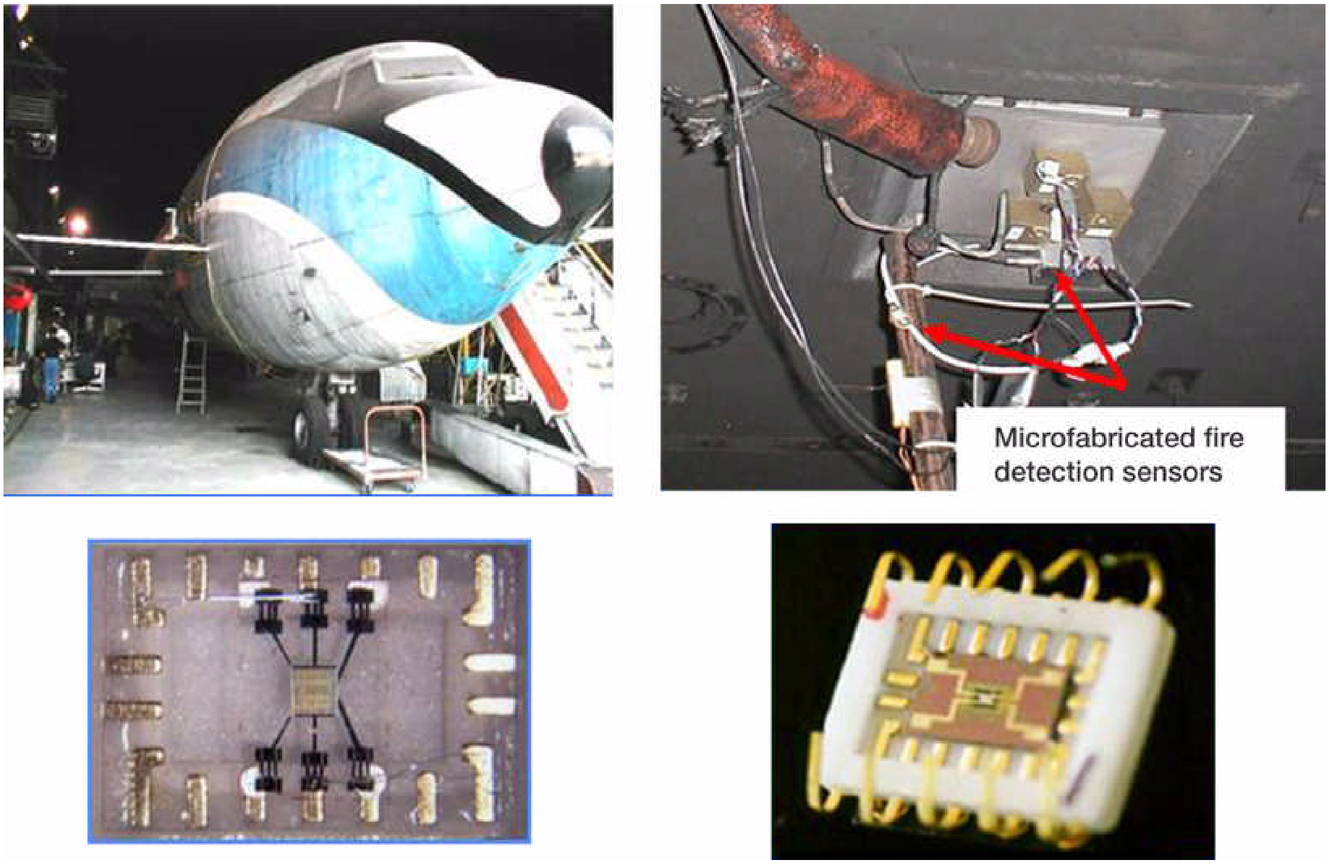
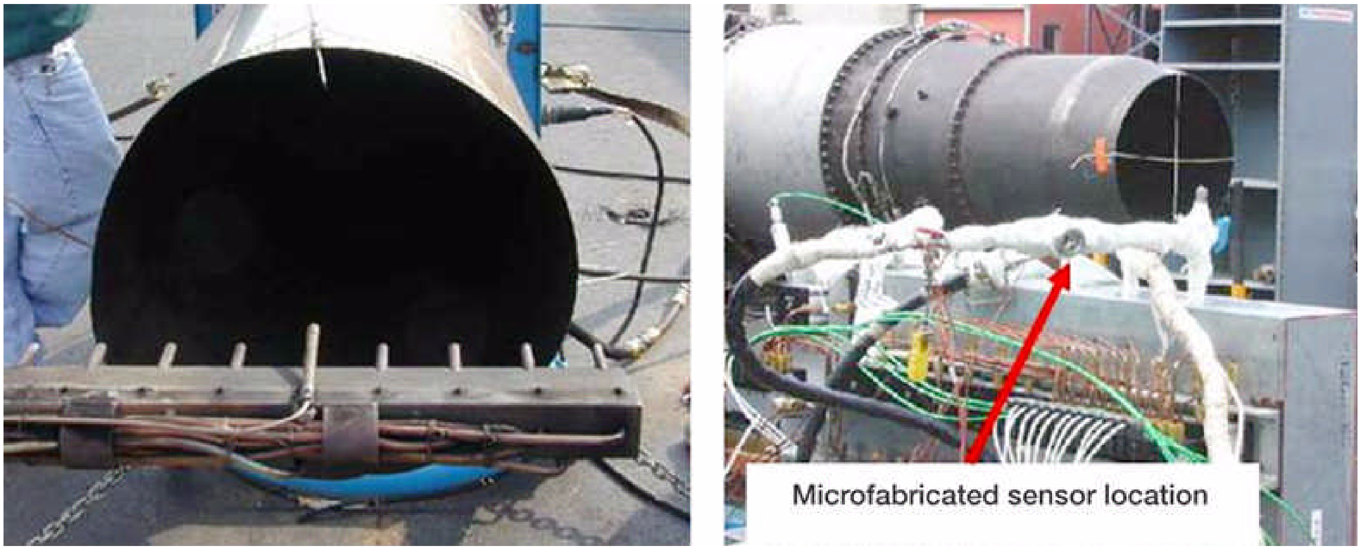
Microfabricated Gas Sensors Demonstrated in Fire and Emission Applications

A range of microfabricated chemical sensors are being developed to meet the needs of fire detection and emission monitoring in aerospace applications. These sensors have the advantages over traditional technology of minimal size, weight, and power consumption as well as the ability to be placed closer to where the measurements need to be made. Sensor arrays are being developed to address detection needs in environments where multiple species need to be measured. For example, the monitoring of chemical species such as carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbons, and other species is important in the detection of fires on airplanes and spacecraft. In contrast, different sensors are necessary for characterizing some aircraft engine designs where the monitoring of nitrogen oxides (NO_x) and CO is of high interest. Demonstration of both fire and emission microsensor technology was achieved this year in a collaborative effort undertaken by the NASA Glenn Research Center, Case Western Reserve University, and Makel Engineering, Inc.



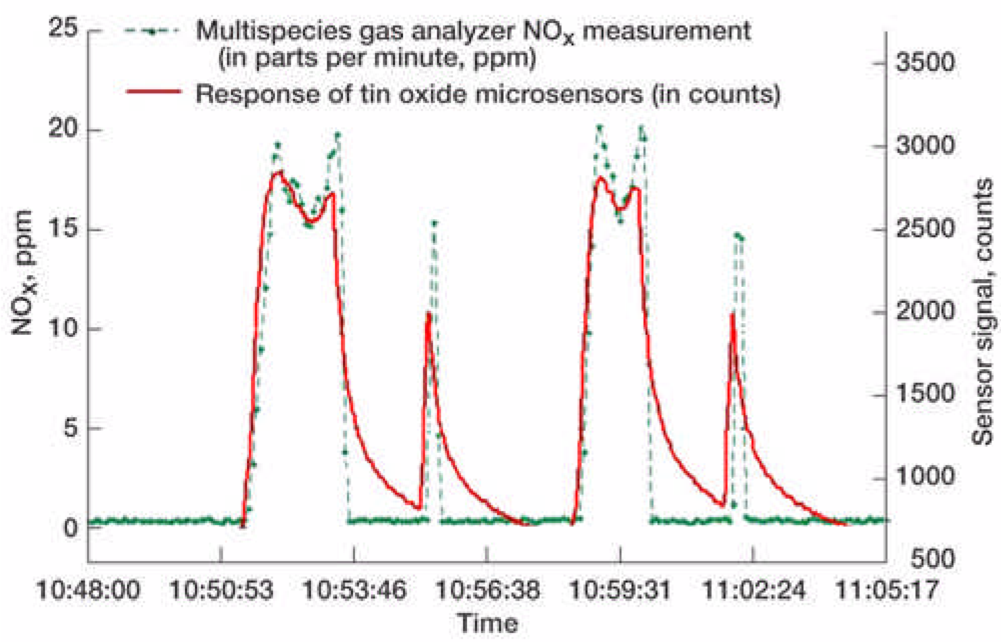
Fire detection testing and microfabricated sensors. Top left: Boeing 707 fuselage used for FAA fire detection testing. Top right: Fire detection sensors installed in an FAA fuselage in which a fire was set and the sensor response monitored. Bottom left: Tin oxide sensor tested. Bottom right: Oxygen sensor tested.

An array of candidate microfabricated fire detection sensors were tested in the Federal Aviation Administration's (FAA) Cargo Bay Test Facilities in a Boeing 707. Controlled fires are set in this cargo bay on a regular basis, and the behavior of the fire and fire detection equipment is monitored in this specially configured facility (see the preceding figure). Microfabricated sensors, including nanocrystalline tin oxide sensors and electrochemical oxygen/humidity sensors, monitored the cargo bay as fires were set. At the onset of several fires in the cargo bay, the sensors showed a very repeatable pattern and appropriate sensitivity and response characteristics. We concluded that the onset of fire can be detected with these sensors. Such chemical information is intended to complement existing fire detection technology and decrease the rate of false alarms.



Microfabricated emissions sensors. Left: The rake sampling system at the outlet of the JT-12 jet engine. Right: Location of the sensors in the flow stream of the rake. The high-temperature operational capability of the sensors allow placement significantly closer to the engine outlet than traditional equipment.

Microfabricated emission sensors were tested in the exhaust stream of a JT-12 jet engine running diesel fuel (see the preceding photographs) in collaboration with the Arnold Engineering Development Center. Samples were drawn through a rake of gas ports as the ports moved across the engine outlet, and comparative data were recorded for both the sensors and multigas analyzers associated with the facility. The sensor’s response qualitatively paralleled the NO_x readings measured by the multigas analyzers as the rake was drawn across various points in the engine outlet (see the following graph). Similar ability of the sensors to parallel the multigas analyzer results were seen in CO monitoring. The recovery time of the NO_x signal differs from that of the multigas analyzers perhaps because of the relative location of the sensors in the sampling stream. However, the advantage of the miniature sensor approach is its relative simplicity and the reduced response time associated with the sensors in the stream in comparison to the remotely located analyzers whose responses are delayed by the time necessary to transport the gas to the analyzers.



Comparison of the NO_x readings measured by the microfabricated sensors and multigas analyzers as the rake is moved across the engine exhaust outlet.

These tests demonstrate the use of microfabricated chemical sensor technology in a range of environments. Further work is necessary to correlate the sensor's quantitative responses with the species generated in both applications and to improve sensor packaging for the specific environment.

Find out more about this research:
Chemical species gas sensors http://www.grc.nasa.gov/WWW/chemsensors/
Glennan Microsystems http://www.glennan.org/

References

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2. Hunter, G.W., et al.: Development of Chemical Sensor Arrays for Harsh Environments. Sensors, 2002, Proceedings of IEEE, vol. 2, 2002, pp. 1126-1133.

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