# Miniature Ion Mobility Spectrometer

## Overview

Ion Mobility Spectrometry (IMS) is an attractive technology for developing a miniaturized chemical sensor. An IMS sensor system has the advantage of operating at atmospheric pressure and is able to detect trace quantities of materials. Current IMS drift tube designs require complex assemblies of electrodes and insulators coupled with electronics to produce the uniform electric fields desired in the IMS drift tube. This results in systems that are not suited for mass production because they are labor intensive and expensive to produce. We have demonstrated a miniaturized, simple to assemble, and inexpensive IMS drift tube constructed from "rolled", low-temperature co-fired ceramics (LTCC) with integral potential resistors. The new LTCC design eliminates as many as 150 individual parts from our current "stacked" design while producing a more chemically inert internal surface.

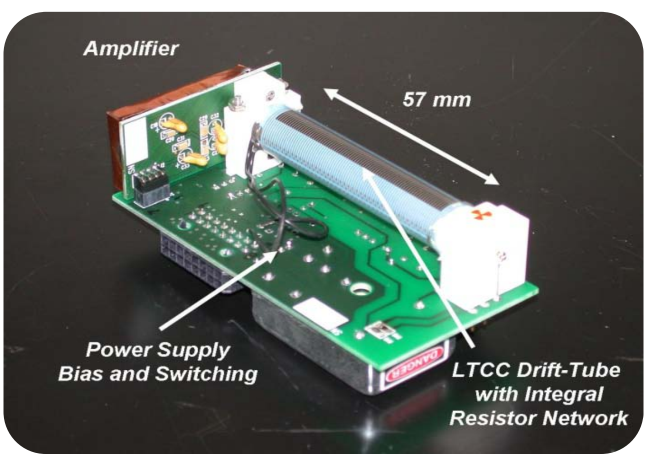


**Figure 1.** IMS tube.

## Applications

- Explosive detection.
- Biological material detection.
- Chemical weapon and drug detection.

## Technical Approach Overview

Ion Mobility Spectrometry (IMS) is an emerging technique that holds promise for a variety of analytical applications. IMS is essentially an ion filter that sorts the mobility (k) of an ionized molecule; mobility is a measure of how fast a molecule will travel under the influence of an electric field in a given atmosphere. Ion drift time (td) is measured across a known tube length (L) with a known electric field (E) and the mobility is given by the following equation:

$$k = \frac{L}{t_d E}$$

IMS tubes can operate in either a positive or a negative ion mode depending on the target species. An IMS requires an ionization source to function. This can either be a radioactive source or other means such as a corona discharge source. Our tubes employ an 241Am similar to a smoke detector source as the ionization source.

## Low Temperature Co-fire Ceramic (LTCC) Drift Tube

IMS drift tube designs for handheld instruments are constrained by several key areas of concern. First, the tubes must be small and lightweight enough for the application. Second, the sensitivity and resolution must be adequate for the application, and finally, the cost of the manufacture and assembly of the tube must be kept low enough to be practical. Low temperature co-fire ceramic technology holds the promise of inexpensive automated drift tube production with minimal part counts and electrical connections to the control and detection circuitry. LTCC allows simple screen-printing operations for the production of the electrodes, and on-board surface mount resistors fabricated directly on the tube to reduce the number of electrical connections required without sacrificing the performance of numerous electrodes (80 electrodes) with small (0.75 mm) spacing. In addition, integral heating elements are incorporated into the structure rather than applied to the outside as in the "stacked" design.

Most of the processing of the LTCC occurs during its "green" unfired state during which it is still pliable. Thus, the processing can be done to flat sheets of material and the tube is then "rolled" onto a mandrel of the desired inner diameter and fired. After firing, the resistors are laser trimmed to within 1% of the desired values and the tubes are dimensionally trimmed. IMS control structures are constructed using LIGA (LIGA is a German acronym that stands for

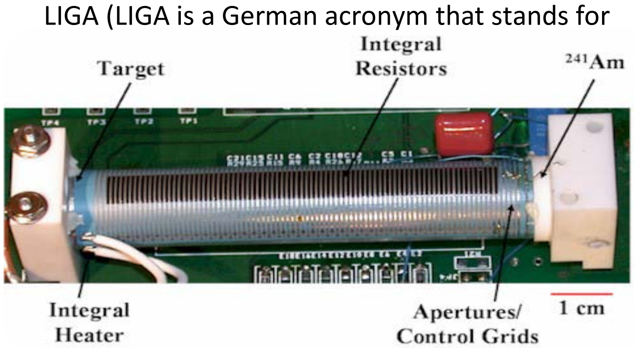


**Figure 2.** Photograph of LTCC drift tube showing Macor ® end pieces, integral resistors, location of 241 Am source, integral heater connections, location of target, and location of apertures and control grids.

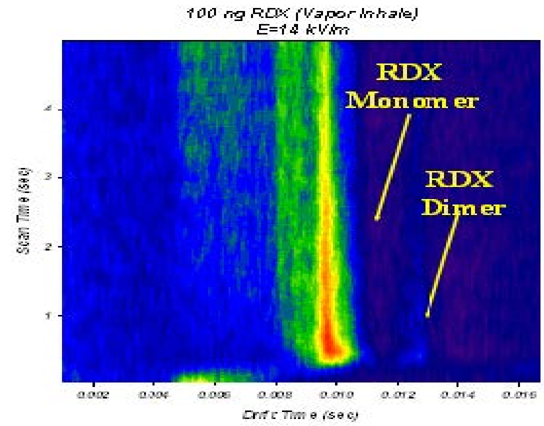


**Figure 3.** Typical data illustrating the operation of an IMS detecting explosives (RDX). Initially the position of the ion peak is around 6ms but moves to the right (10ms) when RDX is injected into the tube. The sensor detects a peak for both the RDX monomer and the RDX dimmer as illustrated. Horizontal axis is the drift time and the vertical axis is the elapsed time.

lithography, electroforming, and molding) processing and are inserted into the tubes and form the gate structures, apertures, and targets of the tube.

## Results

IMS data similar to that shown in Figure 3 can be analyzed manually or using digital signal processing techniques to determine both the species and the concentration of a target chemical. Figure 3 is a contour plot of the output with the horizontal axis representing the drift time through the IMS tube and the vertical axis representing the elapsed time of the experiment. This particular data is for a 100 ng vapor inhale of RDX and shows both dimer and monomer peaks in the response. IMS has also been demonstrated in a variety of other applications from chemical agent detection to illegal drugs and health applications.

## References

1. Peterson, K. A.; Rohde, S. B.; Pfeifer, K. B.; Turner, T. S.; 204th Meeting of the Electrochemical Society held October 12-17, 2003 in Orlando, Fl.

**For additional information or questions, please email us at Microsystems_App@sandia.gov.**

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