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Micro Total Analytical Systems Department Overview

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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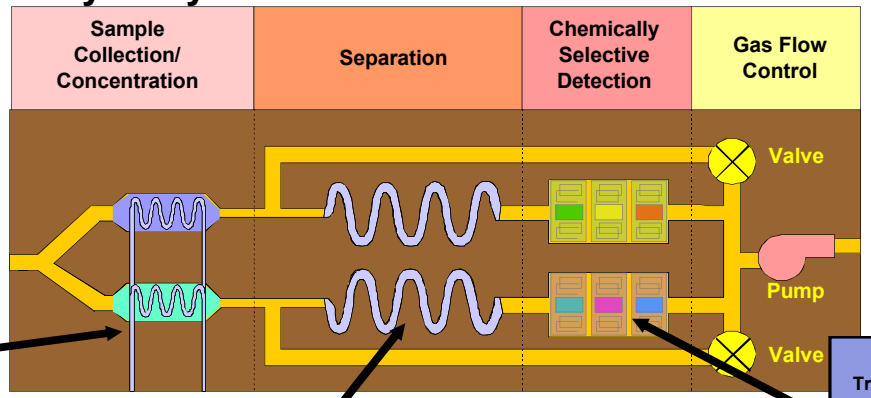
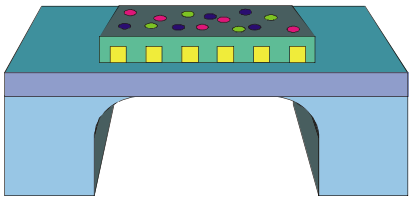
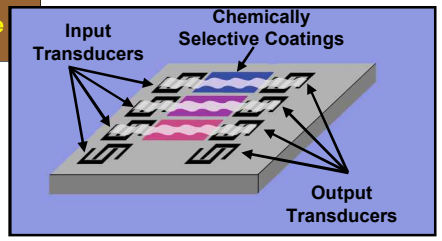
Field Portable Chemical Analysis System

A hand-held chemical analysis system that uses three microfabricated analysis stages



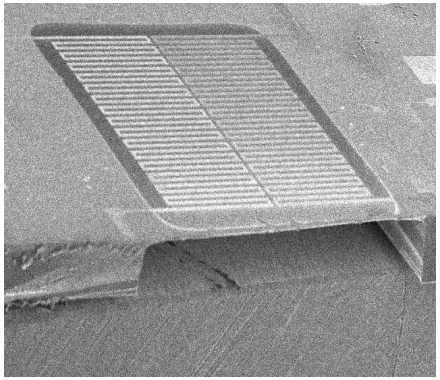


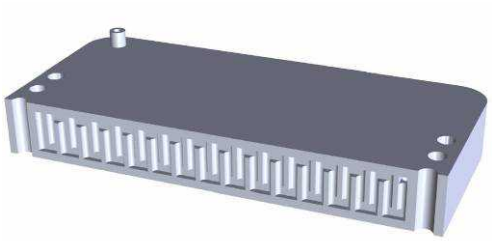


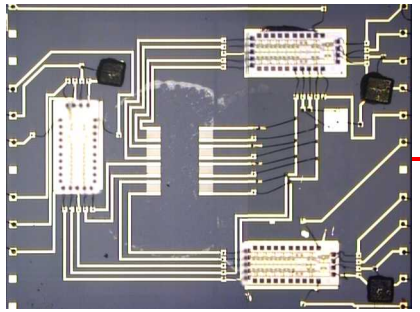
Preconcentrator accumulates species of interest

Gas Chromatograph separates species in time

Acoustic Sensors provide sensitive detection







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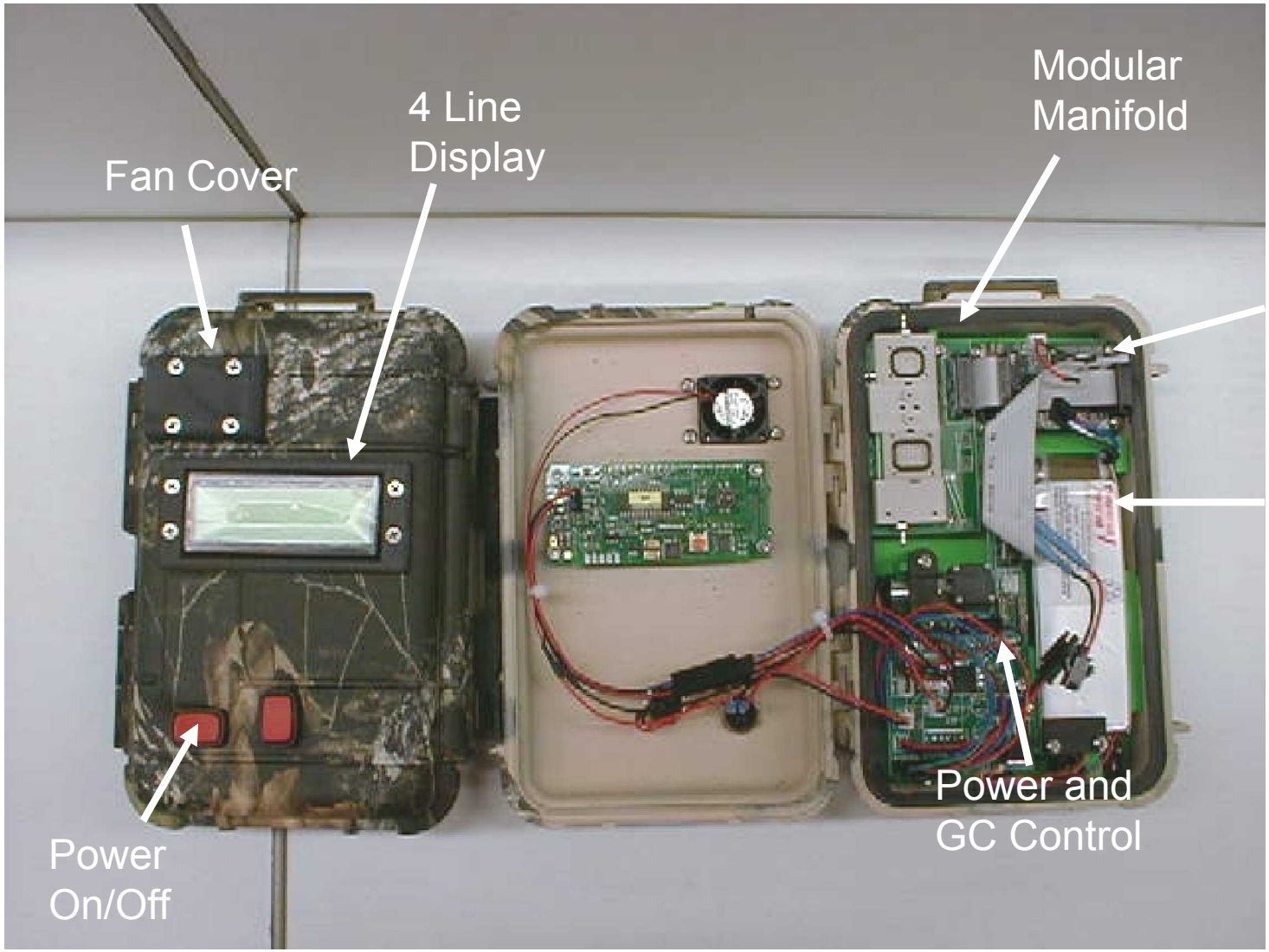
Handheld Chemical Analysis System



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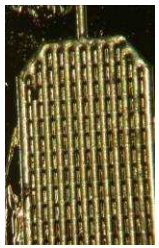
Micro Analytical System Components

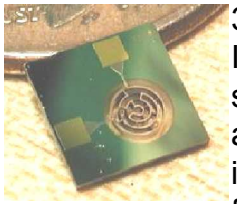
Field Tested — Technology Maturity Level — Requires More Development

Sample Collection

Planar PC Sharp sample inject – most mature



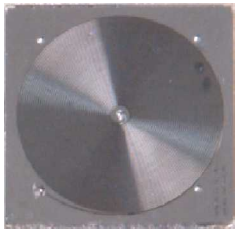
Tortuous Path PC better retention even for VOCs



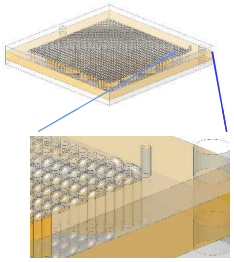
3d PC Increased surface area and improved flow contact

Smart PC – enables intelligent operation and greatest dynamic range (miosis to IDLH)

Separation

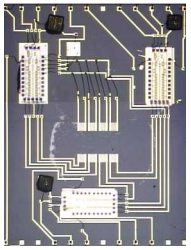


High aspect ratio column in silicon



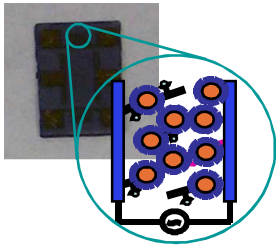
Circular x-section column made in Ni using LIGA. Highest resolution separation

Detection

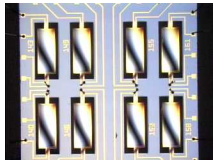


SAW Array with integrated electronics for DC-in;DC-out operation.

Micro Flame Ionization Detector → "universal" GC detector.



Organic / Nanoparticle based detector for low power high sensitivity CW detection.



Pivot Plate resonator for high temp applications.

Micro Nitrogen Phosphorus detector the most sensitivity with the greatest rejection of interferences.

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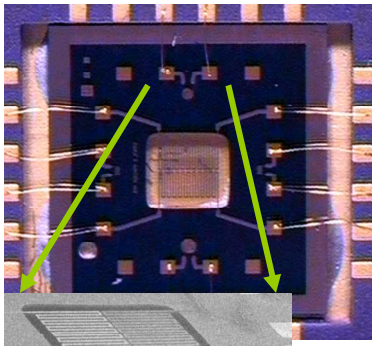
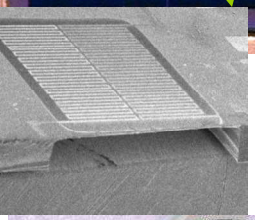
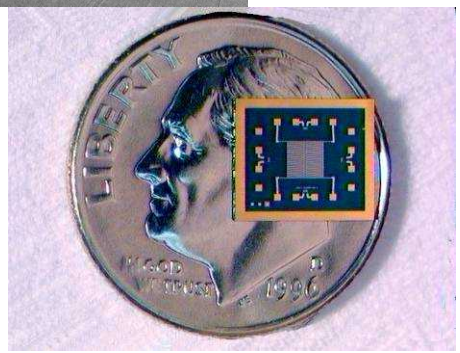
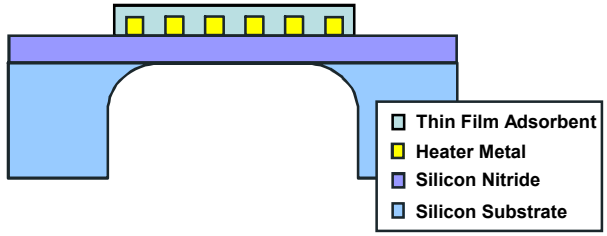
Preconcentrator

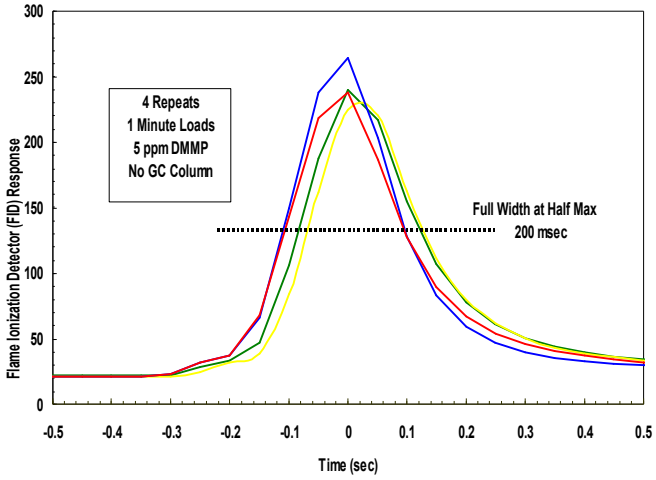
Thermally Isolated Heater Provides Rapid and Low Power Thermal Desorption of Analyte Collected into Thin Film Adsorbent





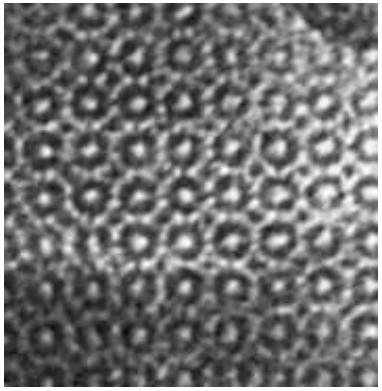




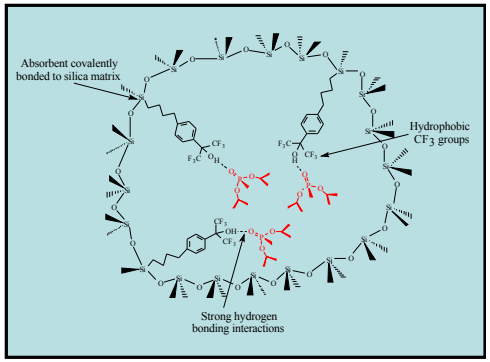


Rapid Thermal Desorption from Micromachined Preconcentrator

Novel Sol-Gel Techniques Provide Thin Film Adsorbents with High Uptake and Chemical Selectivity



Tailored Porosity



Tailored Surface Chemistry

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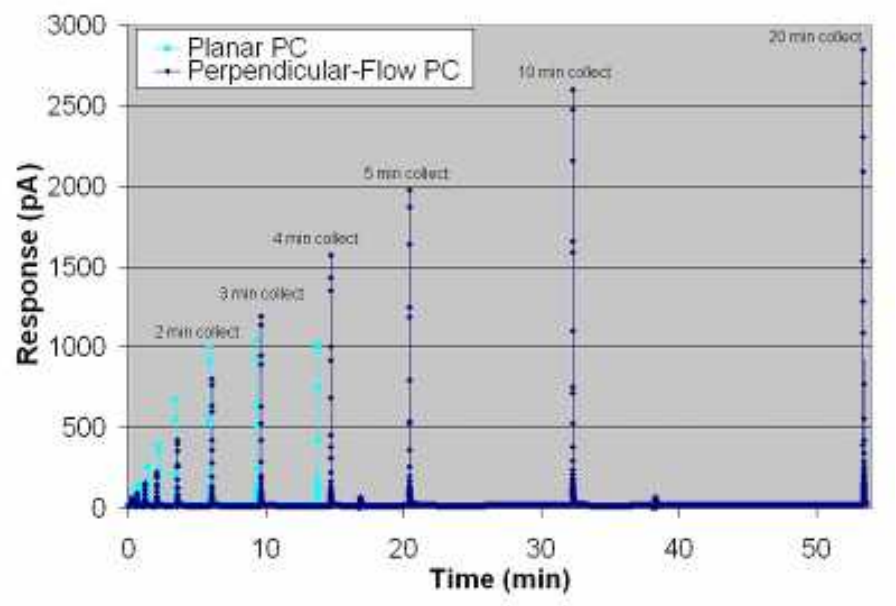
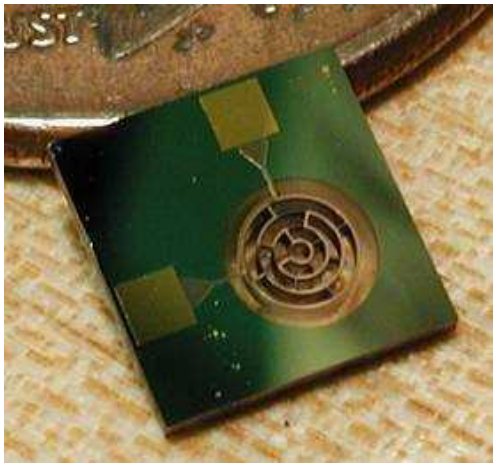
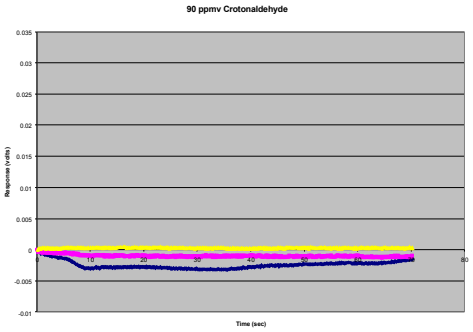
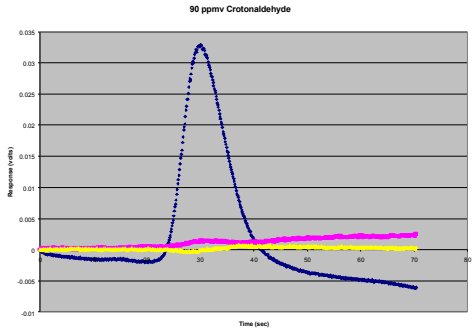
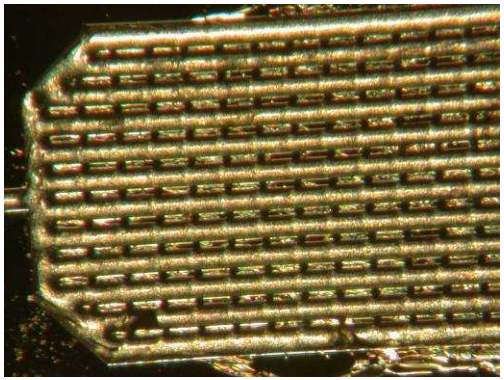
High Capacity micro-Preconcentrators











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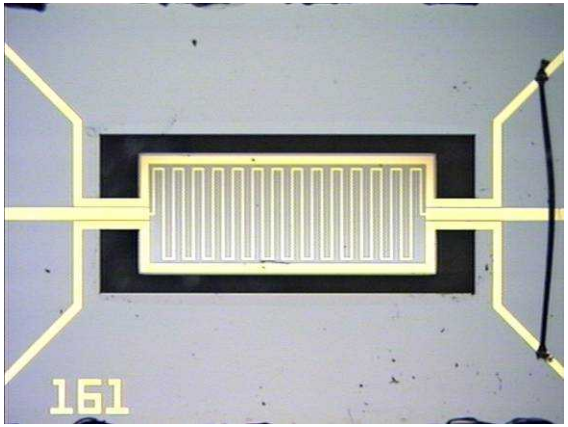
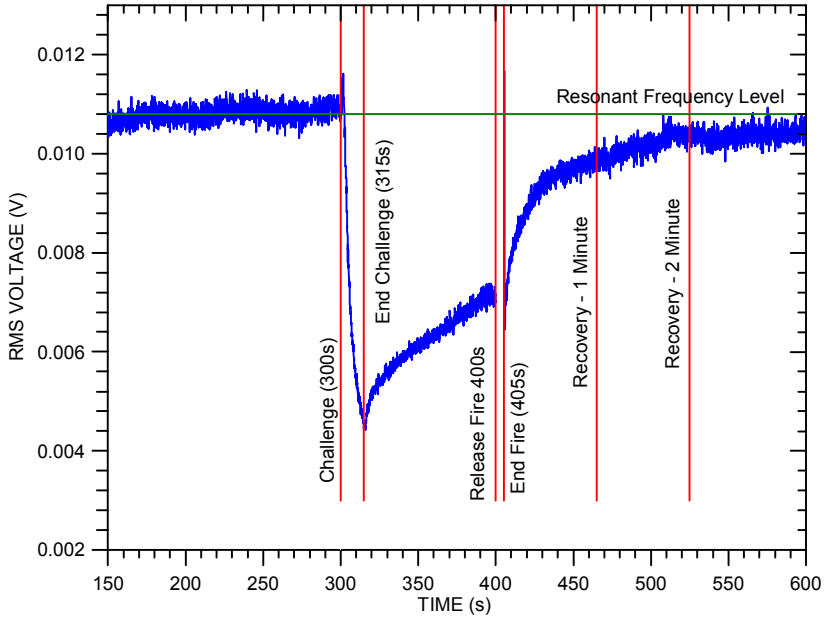
SMART PC Tests



Tests on device TTH3-06
- Coated with 2 µg of Solgel
- Resonance at 11584 Hz
- 74 ohm heater

SMART PC tests
- Paddle at resonance, 11584 Hz
- DMMP challenge
- Challenge removed – 85s hold
- 5s fire on heater
- Recovery in ~120s



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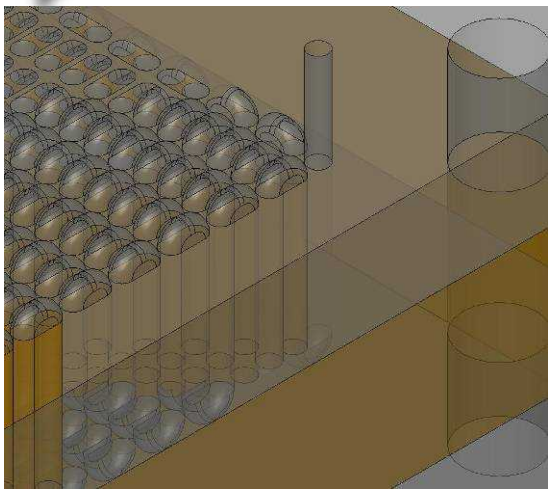
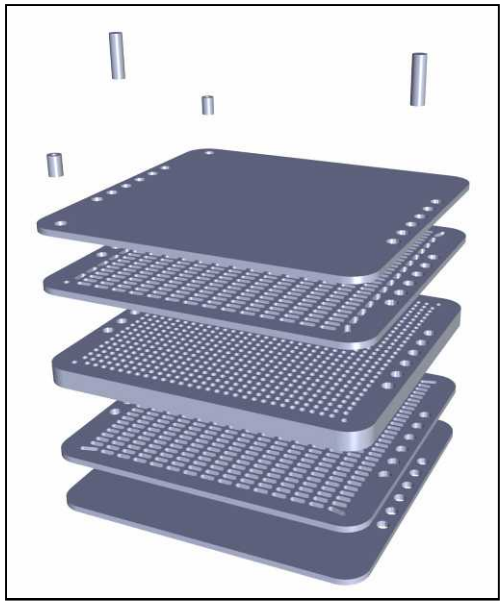
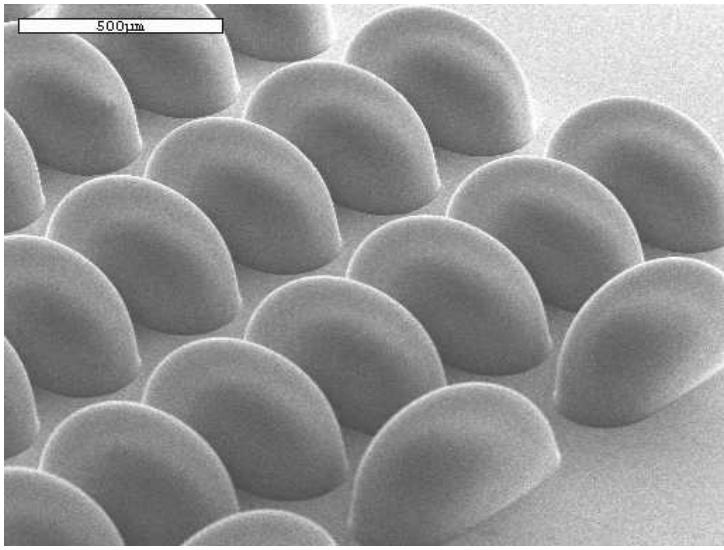
Nickel LIGA RTA Columns



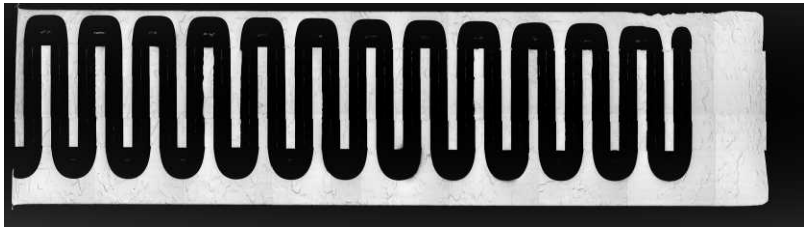
Exploded View of LIGA fabricated GC





LIGA Molds for Rounded Turn Arounds.

New Circular X-Section GC Column to minimize band broadening. Longer columns can be made by stacking center sections



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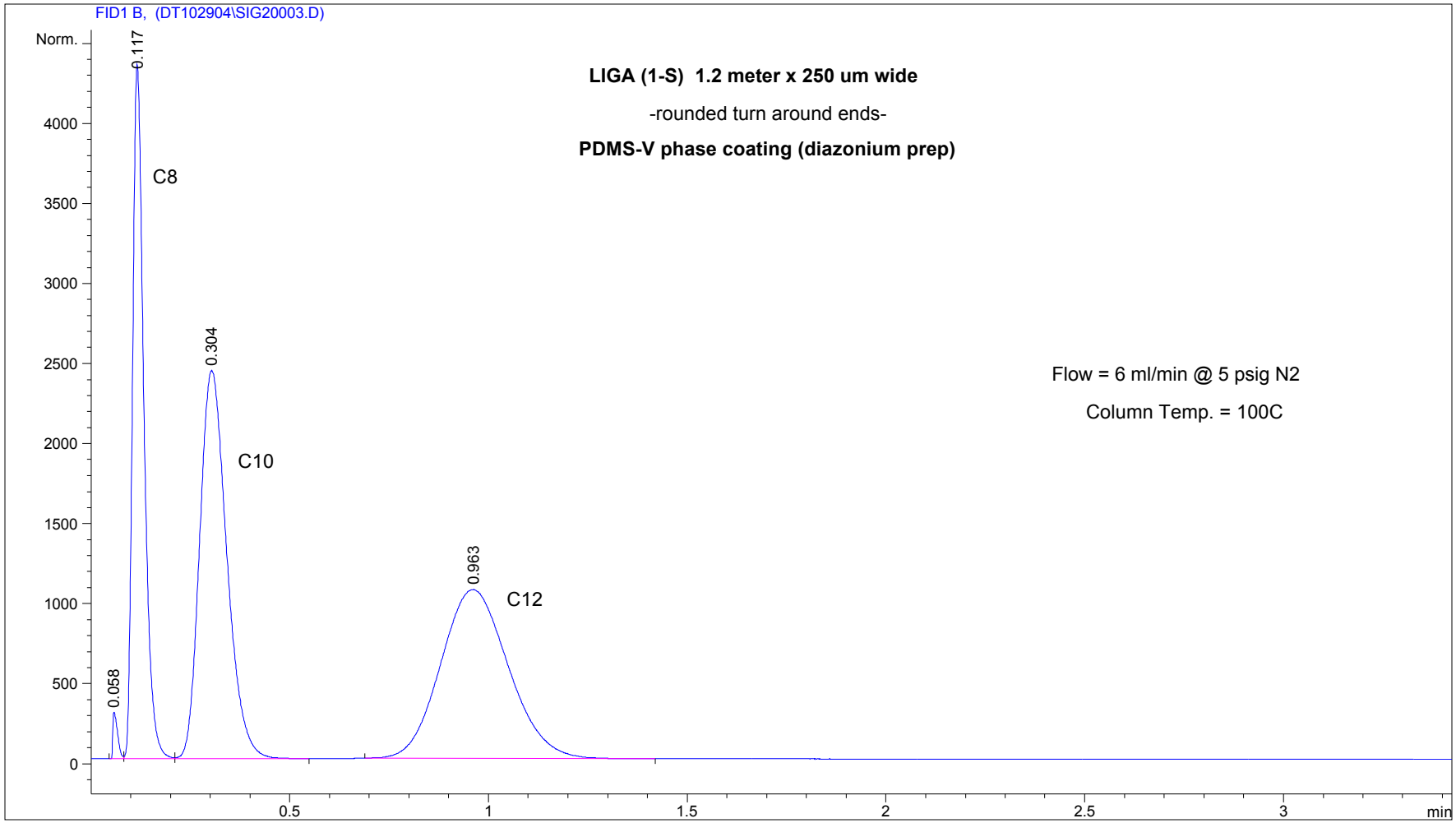
Homologous Series



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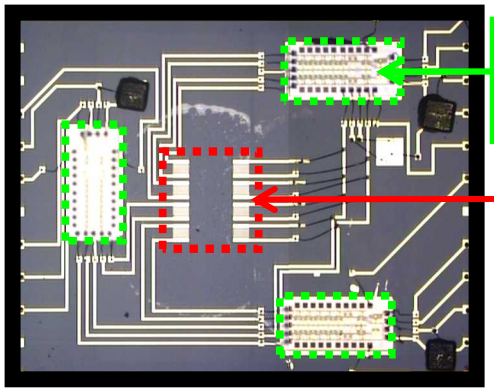
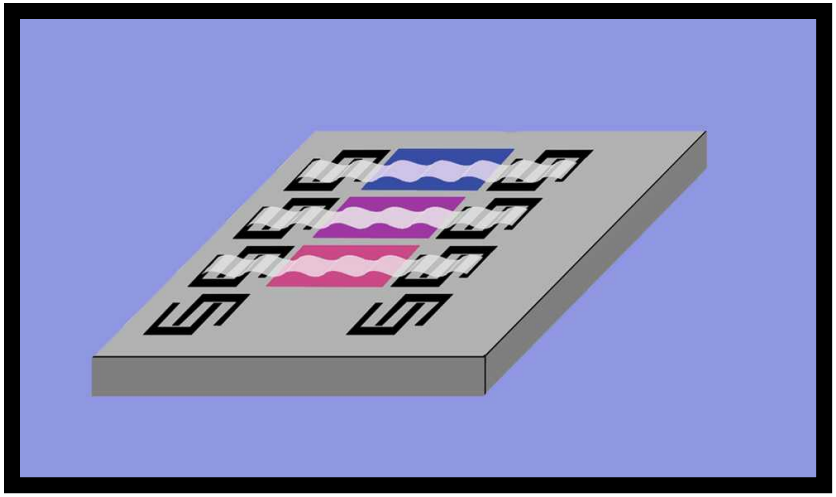
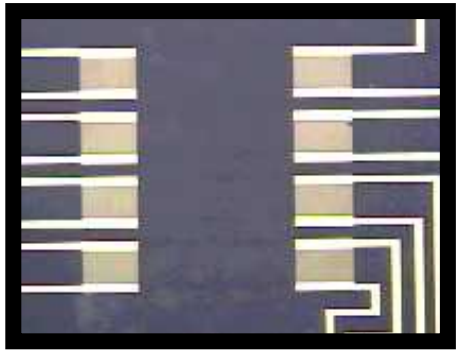
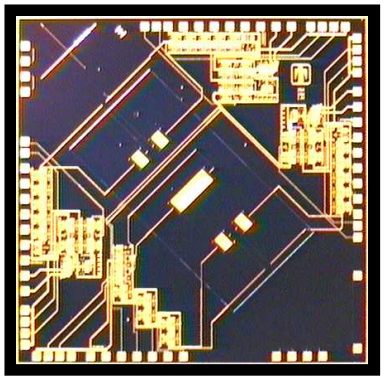
Surface Acoustic Wave (SAW) Detector

- Surface acoustic wave is excited/detected using interdigital transducers on a piezoelectric substrate
- Sensor coating momentarily absorbs analytes eluted from GC column, changing SAW velocity (phase shift).
- Pattern of responses from array augments discrimination of GC separation









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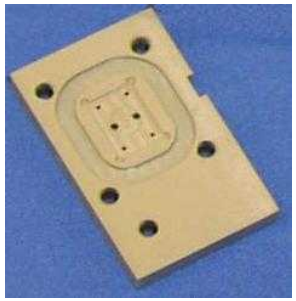
Modular Manifold for Gas Components

- Modules can operate in parallel to maximize analytes and minimize time
- Different modules can be added to change detector or preconcentrator
- Easy to replace components to facilitate testing different films
- Each piece makes electrical and fluidic connection

Preconcentrator manifold



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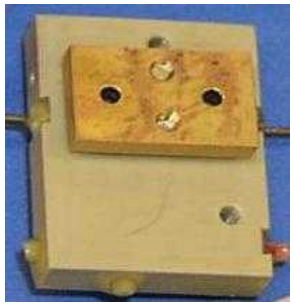
GC Column manifold



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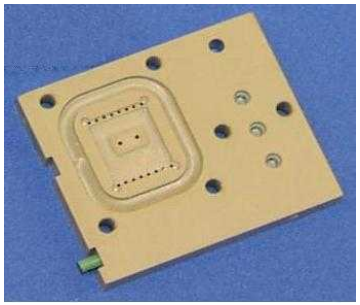
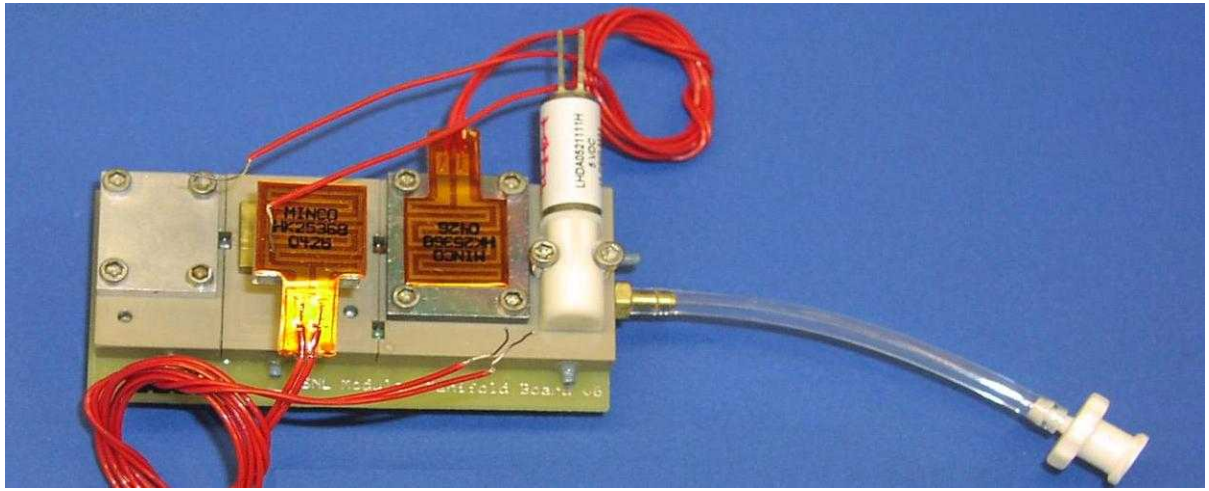
SAW Array Manifold



Adding modules together results in an easy to use manifold



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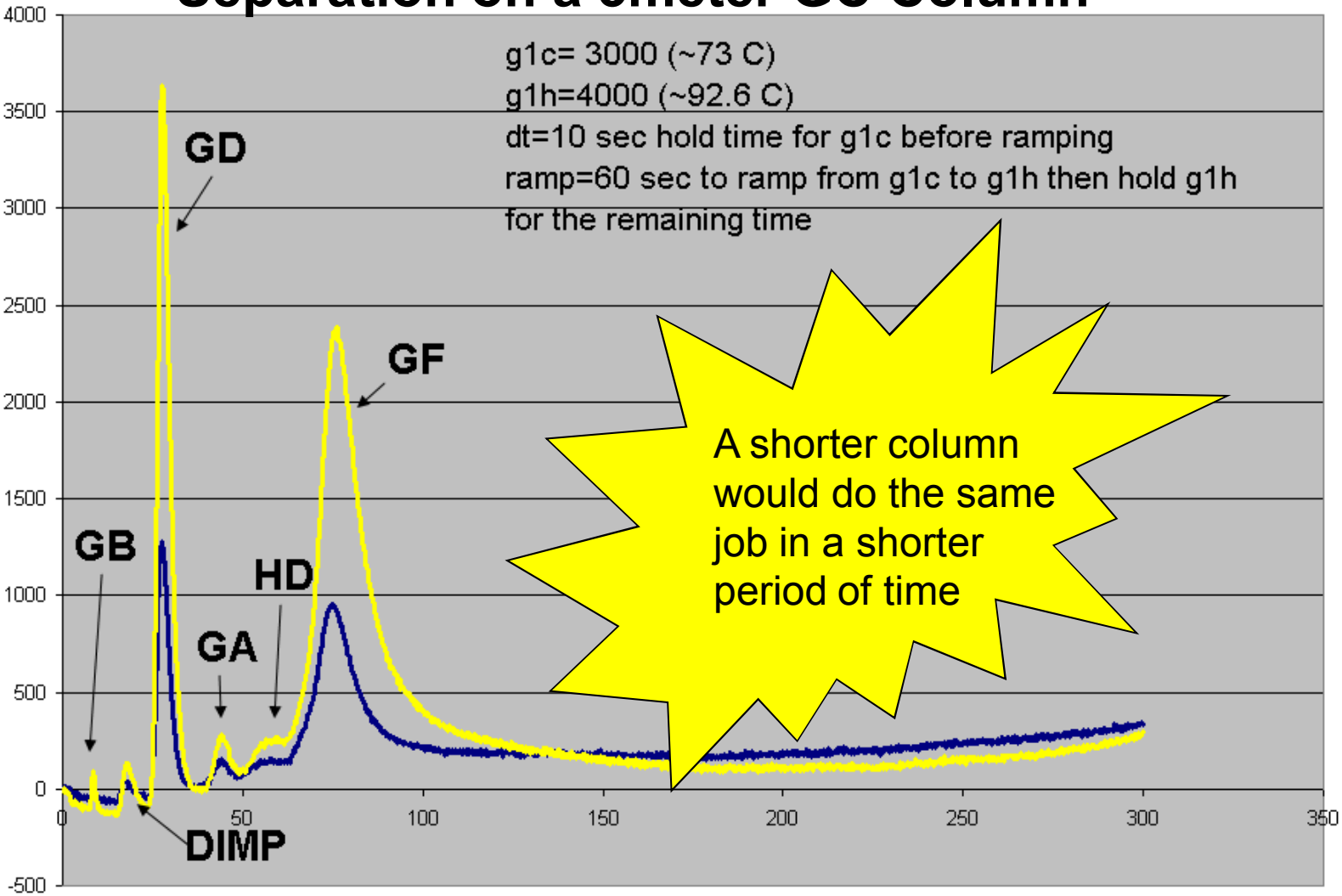
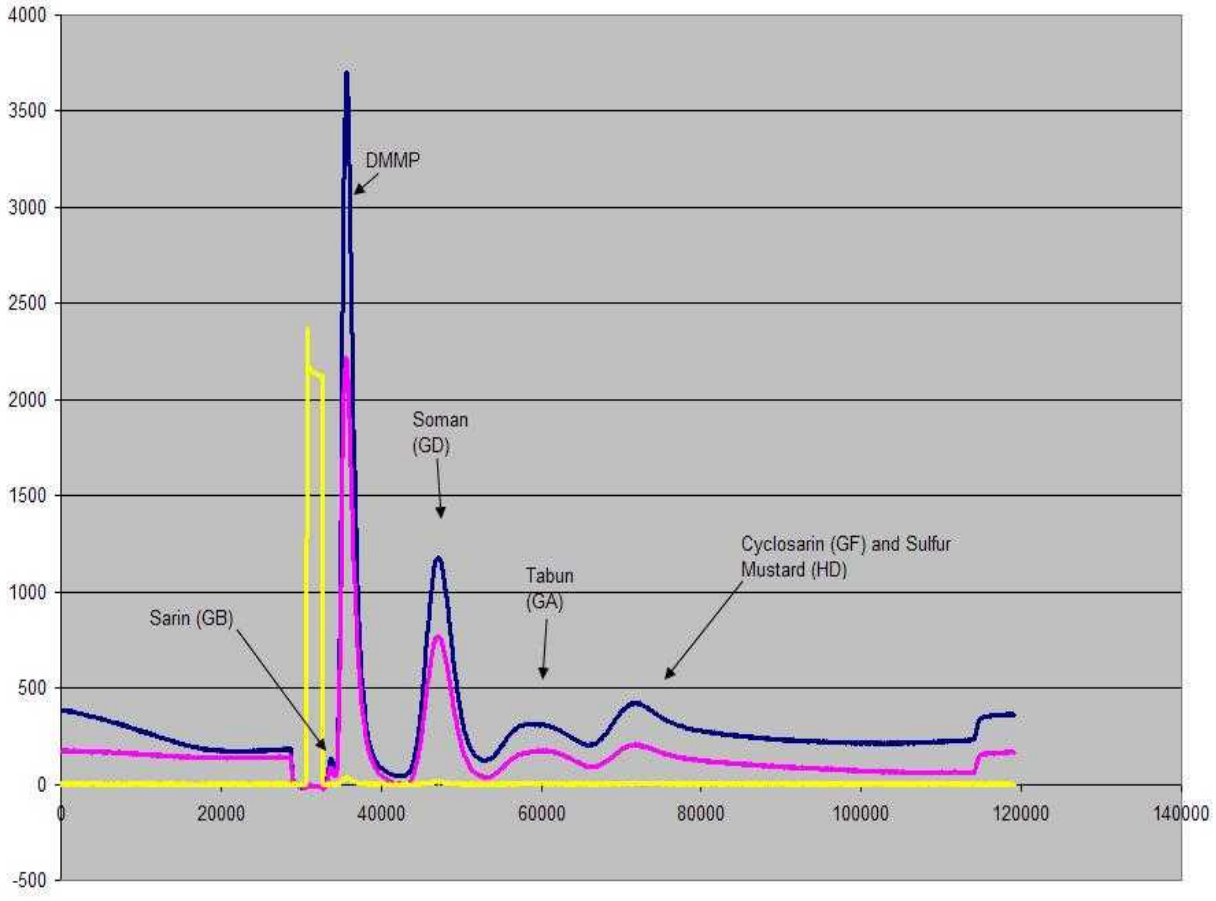
CW Agent, Byproduct, and Blister Agent Separation on a 3meter GC Column

Some detectors will merely tell you "Nerve" or "Blister". Our GC column enables this system to report which nerve or which blister.



Handheld System Separating 5 Target Chemicals



Onboard Calibration and peak searching provide Chemical name and concentration to a 4 line display

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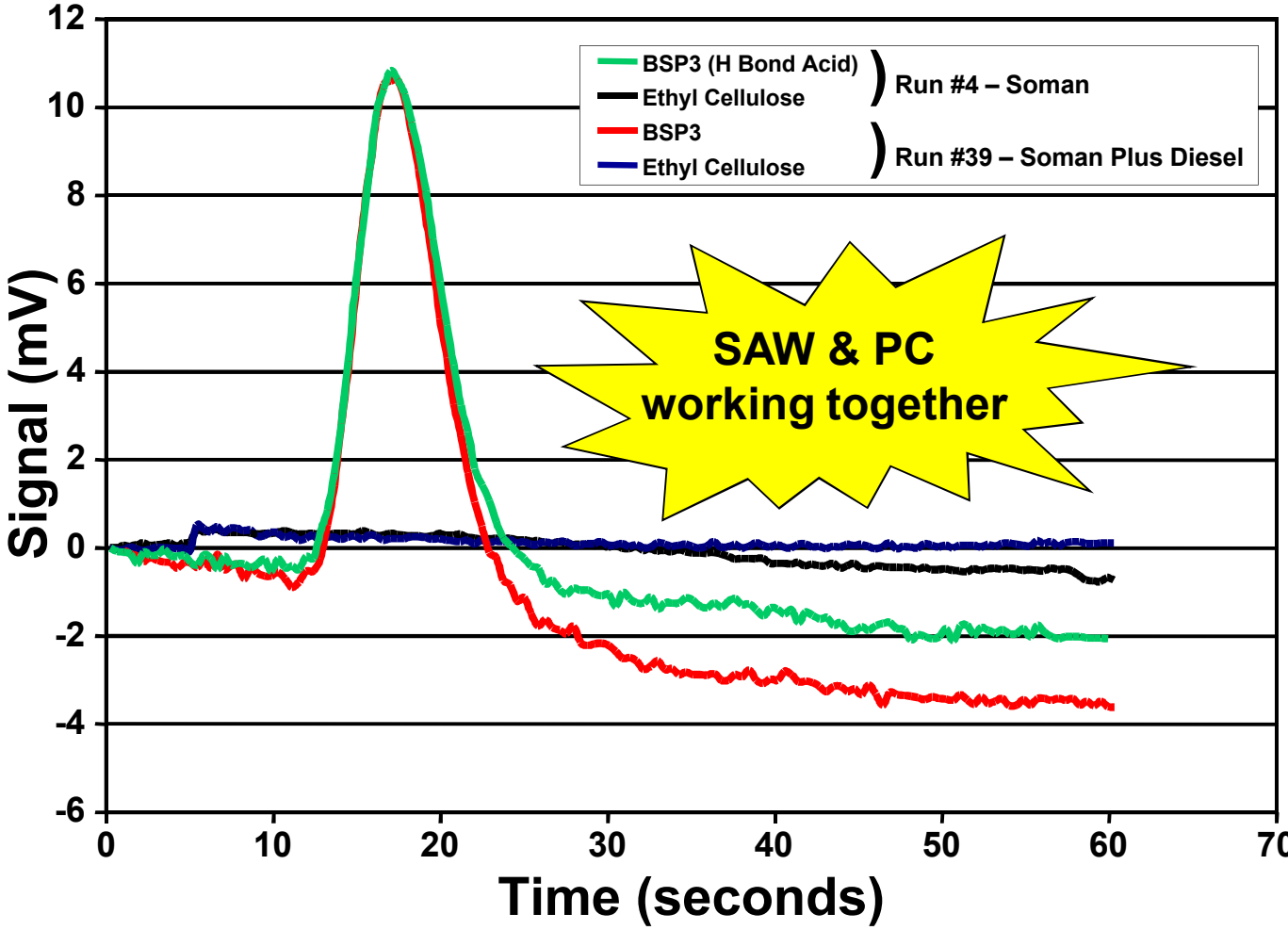
Selective Preconcentration of GD in High Background of Diesel



Two analyses overlaid. In one only GD is present, in the second the same concentration of GD is in a high background of diesel.

There is no change in response or retention time, the diesel is ignored by the front end preconcentrator material.

A special acknowledgement for Kwok Ong and the Applied Chemistry Team at ECBC for providing the test environment for this evaluation.

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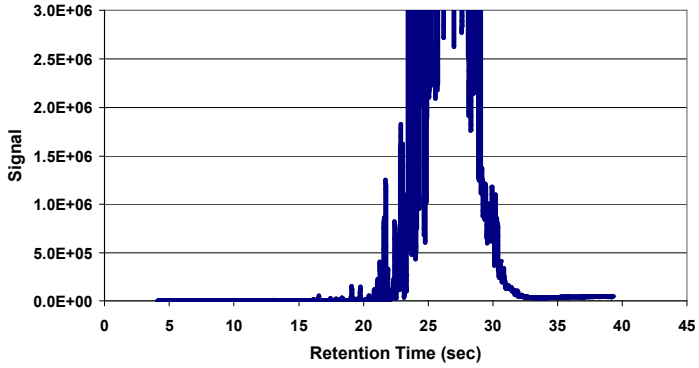
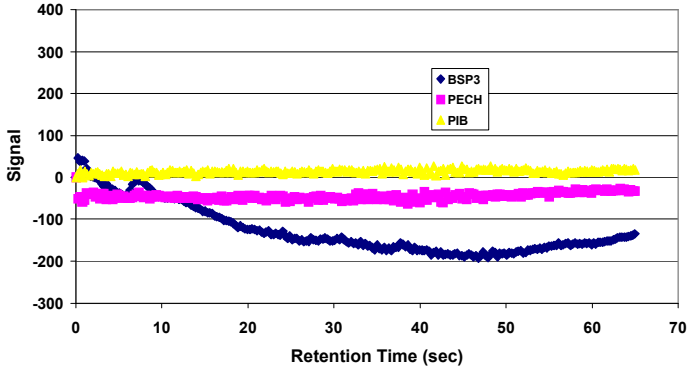
The μChemLab is insensitive to petrochemical (JP8) interferent



TD/GC/MS from Shop Floor



μChemLab from Shop Floor

Thanks to SBCCOM and KAFB Refueling Shop

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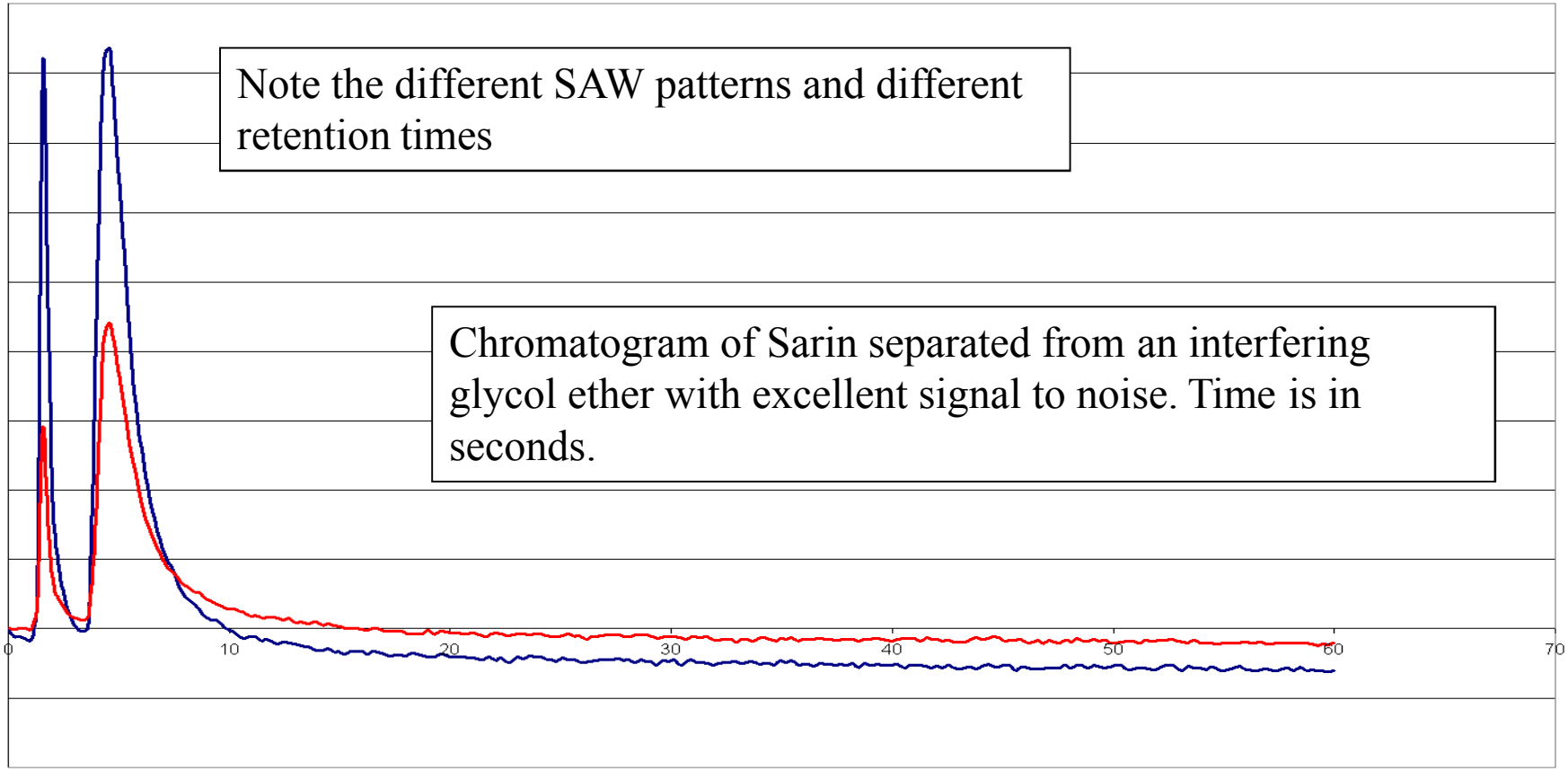
Separating Interferences Resolving Sarin and Diethylene Glycol Ethyl Ether



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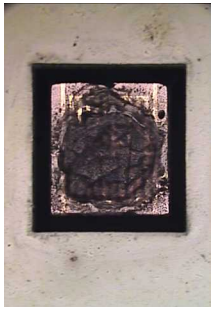
Micro Nitrogen-Phosphorus Detector Operating Principles

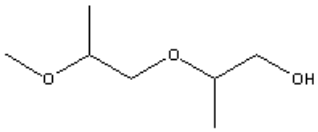
An example of one of the thermally isolated low power heated surfaces used as a basis for element specific detection

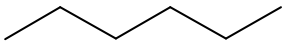


An alkali metal hydroxide catalyzed sol-gel is used as a low work function surface. Thermochemically formed electronegative radicals abstract an electron from the hot sol-gel surface.

Unlike COTS NPDs, the Sandia μNPD operates in both phosphorus and nitrogen specific modes without hydrogen gas – ideal for fieldable portable detection systems

This detector gives only a minimal signal for fuels and industrial solvents.





The signal is maximized for phosphorus or nitrogen containing compounds (*e.g.,* nerve agents, many TICs).

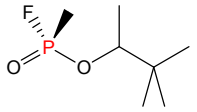
Typical TIC's

HCN ClCN NH_3

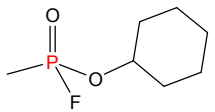
CH_2=CHCN

CH_2=CHCHO

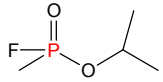
CWA's



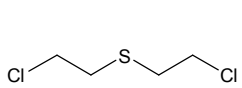
Soman-GD



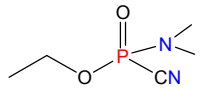
Cyclosarin-GF



Sarin-GB



Sulfur mustard-HD



Tabun-GA

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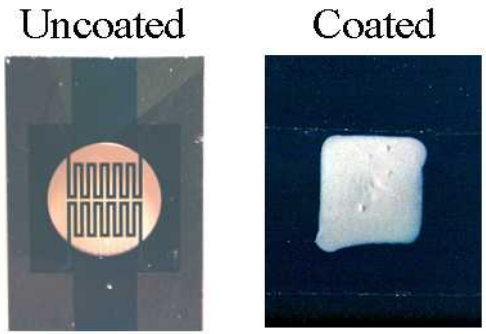
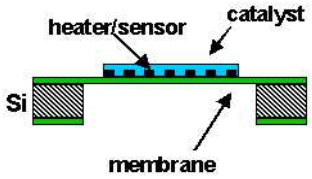
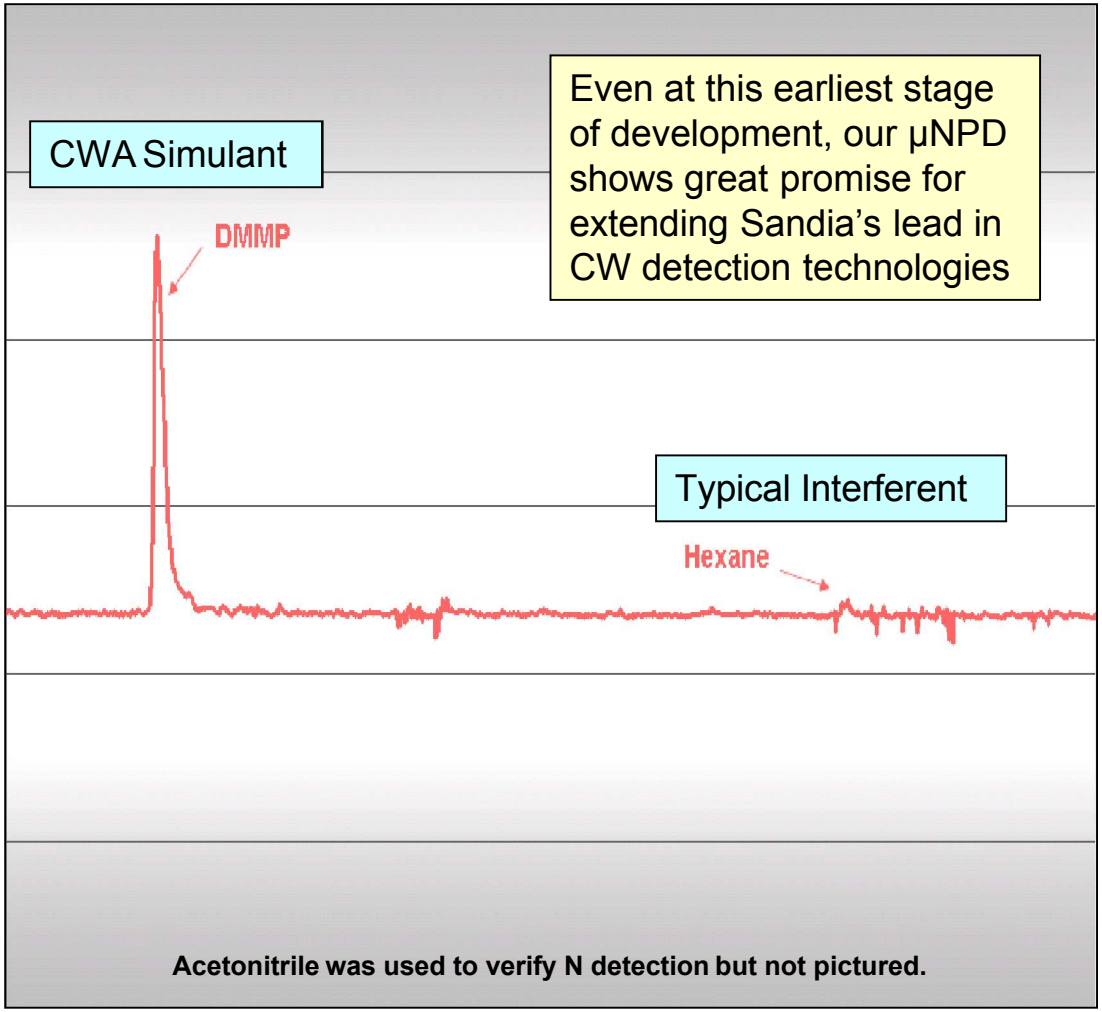
Sandia μNPD Preliminary Lab Prototype Results

NPDs are capable of detecting N and P at a ratio of up to 100,000:1 over carbon with picogram sensitivity.

By comparison, our Sandia SAW detectors (RL6) have at best 100:1 relative sensitivity.







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Conclusion
Sandia's Micro Chemical Analysis System

- Very sensitive and selective
- Low false alarm rate
- Can be designed for many different analytes
- Field Proven technology

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