SAND2011-4365C

Smart Microfabricated Preconcentrator (and Other Micro Analytical Detection Components & Systems)

Ron Manginell, Ph.D., Sandia Labs, Albuquerque, NM
rpmangi@sandia.gov

Workshop on Novel Sampling and Sensing for Improving Food Safety

Georgia Tech, Atlanta, GA, June 16-17, 2011

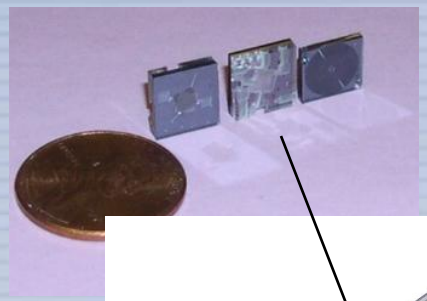
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

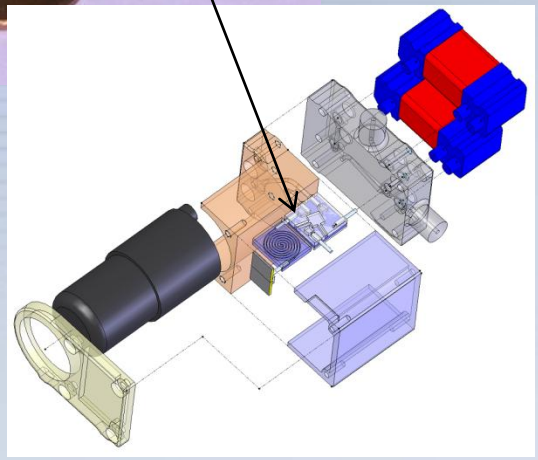
Sandia National Laboratories

Overview of MicroAnalytical Systems: Handheld, MEMS-Based, Portable Detection

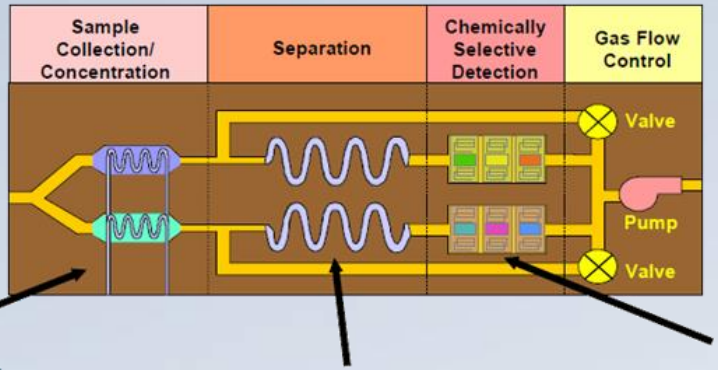
Sandia's MicroChemLab
SVOCs, solvents, water, FAMEs
IEEE Sensors Journal, 6 (3) 784-795 (2006).

www.defiant-tech.com



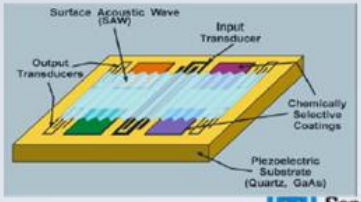


Sandia's Phase II MGA (DARPA)
SVOCs, VOCs
Transducers 2009, 1666-1669.



Trap

Separate

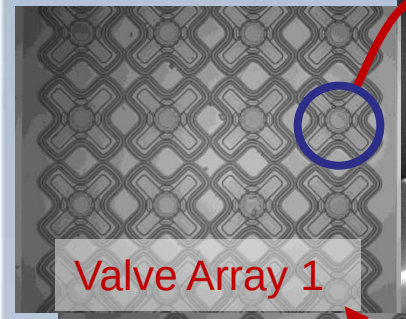


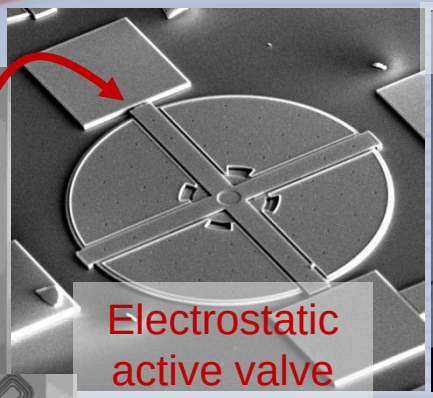
Detect

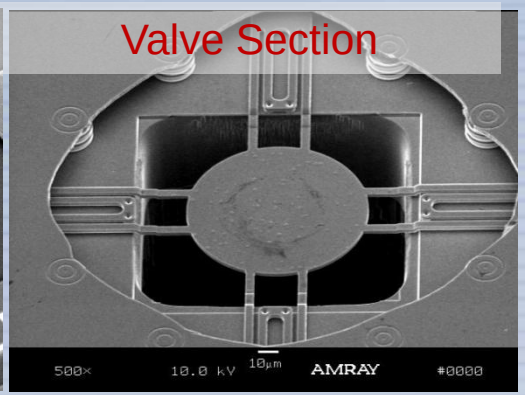
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

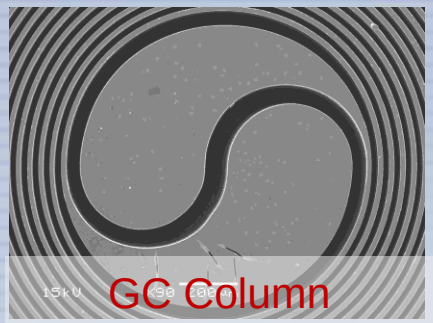
Sandia National Laboratories

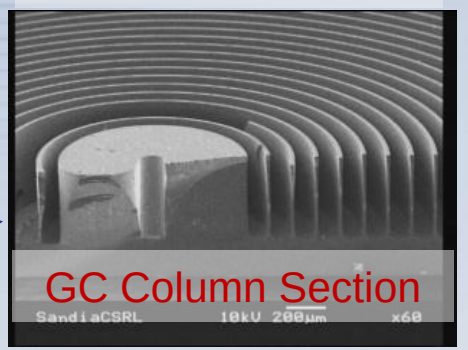
Sandia's Phase IV MGA (for DARPA & DTRA) Components and System

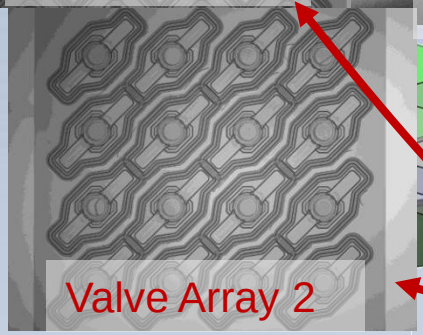

Valve Array 1

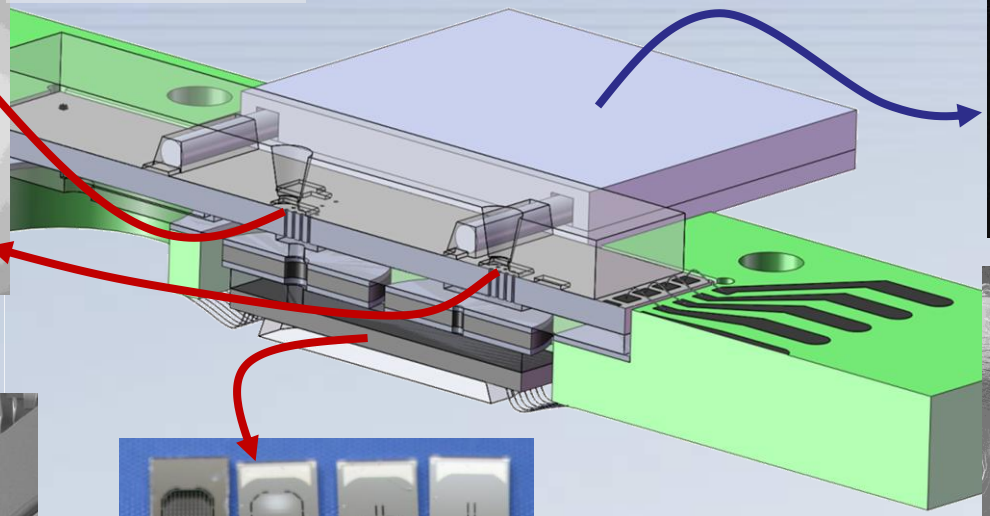

Electrostatic active valve

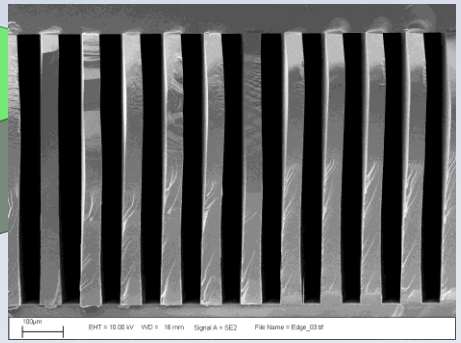


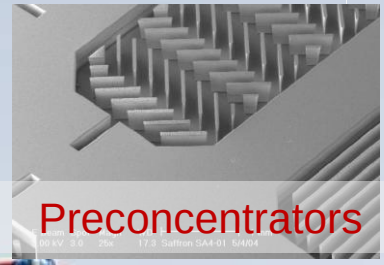


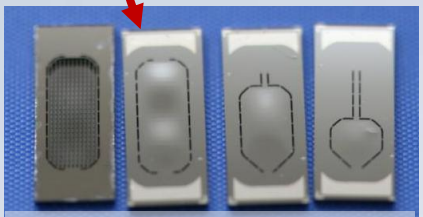



Valve Array 2




High Mag GC


Preconcentrators

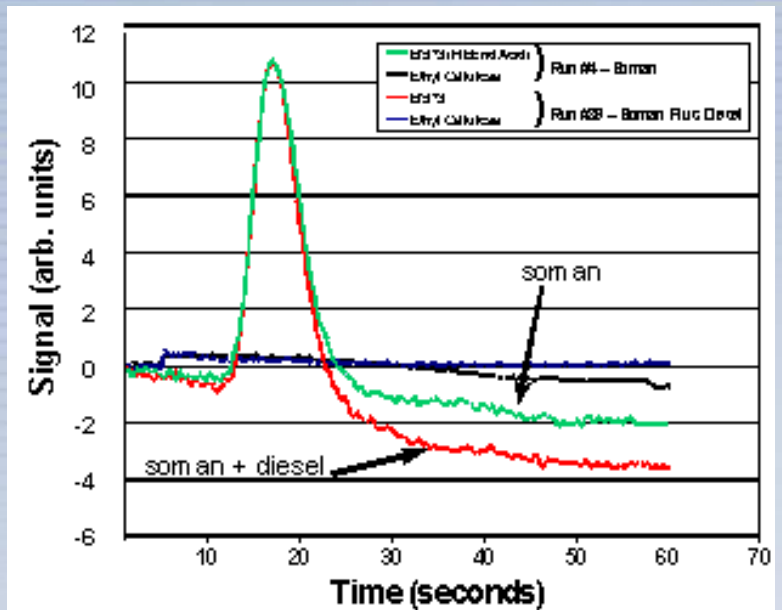

Preconcentrators

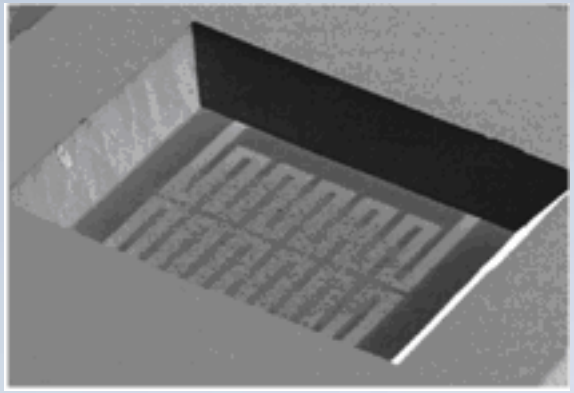
LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

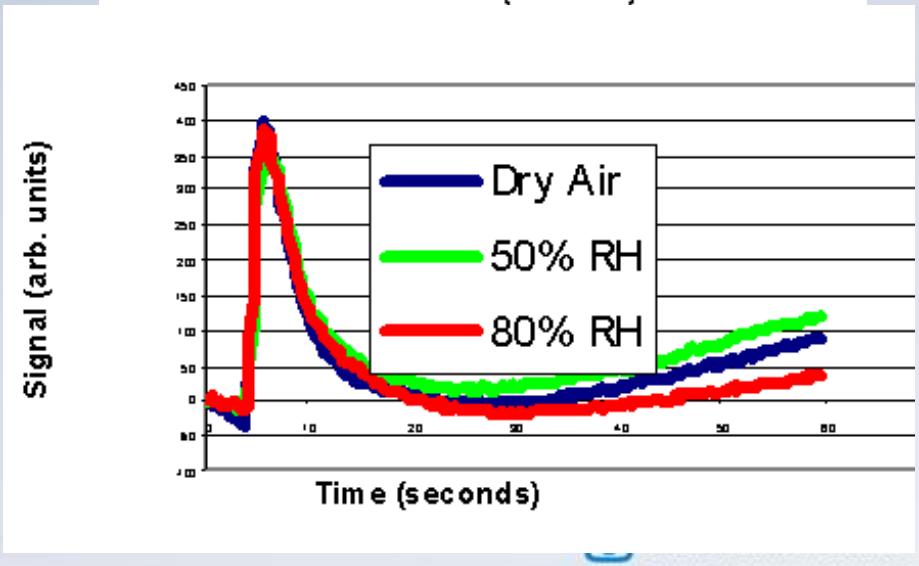
Sandia National Laboratories

Planar MicroFabricated Preconcentrators

- **High efficiency adsorbent platform**
  - 2000°C/W; 10msec ramp
- **Minimal flow restriction**
  - 5 psig, 200 mL/min
- **Concentrate targets**
- **Reject interferants**
- **A non-mechanical GC injector**

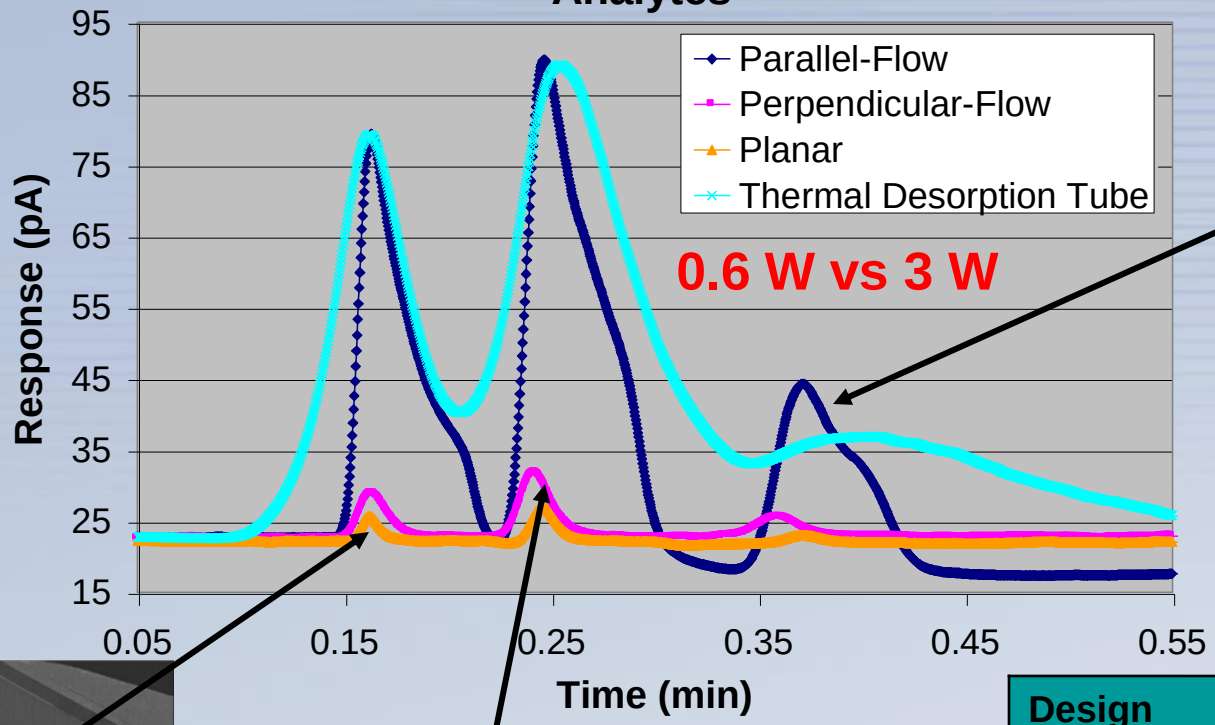


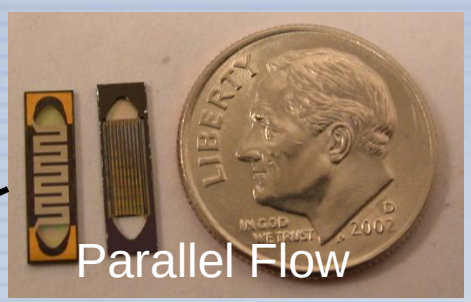




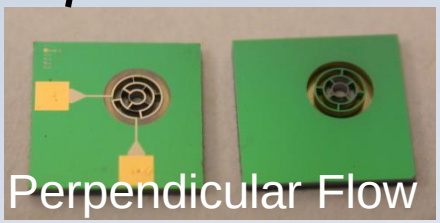
Comparison of sample collectors with SVOC coating: Superior collection and desorption to conventional VOC-tuned design for volatile TICs

Preconcentrator Device Comparison with TIC Analytes





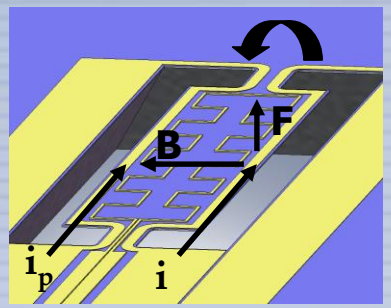
VOC identification bacterial pathogens:
M. Bruins et al., Eur J Clin Microbiol Infec Dis, 28, 775-780 (2009)

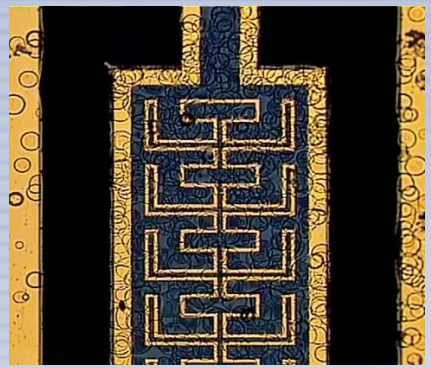


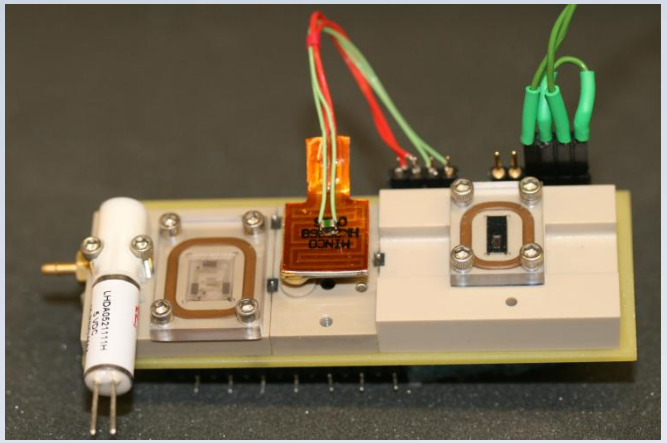
Design	t90 to 200C	Power
Planar	10 msec	100 mW
3D	0.6-1 sec	200-600 mW
Tubular	~minutes	~watts

Smart Microfabricated Chemical Preconcentrator

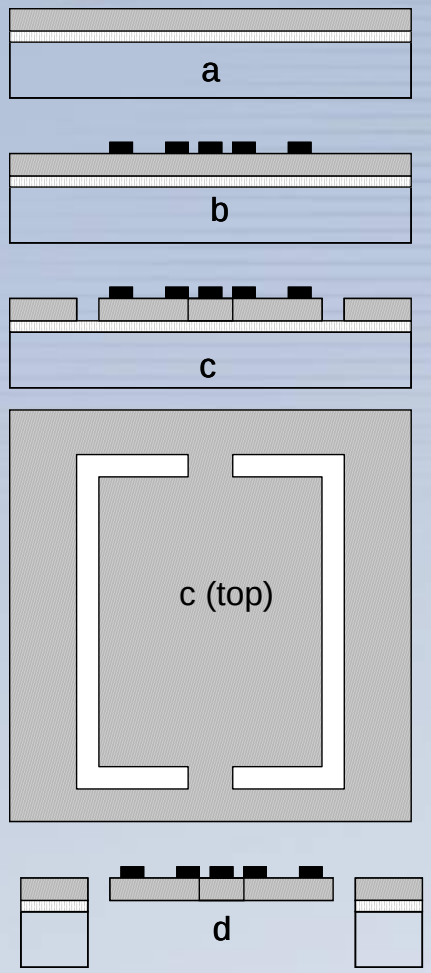
- Preconcentration for field detection
- The Smart Preconcentrator (SPC) combines sensing & preconcentration
- SPC is the first PC to autonomously decide when to initiate an analysis
- 0.6 second collection at LC50 of Sarin; <50 ppb LOD
- SOI fabrication
- Modular microsystem packaging
- Self-tuning control/sense circuit
- Theory for optimization

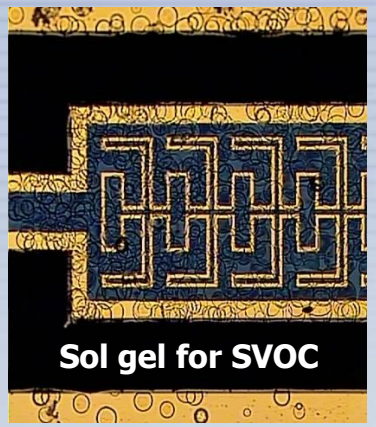




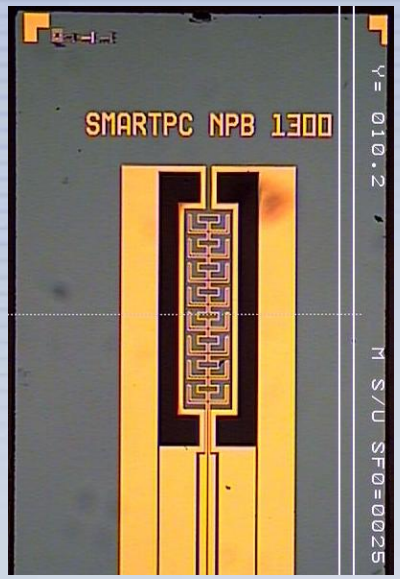


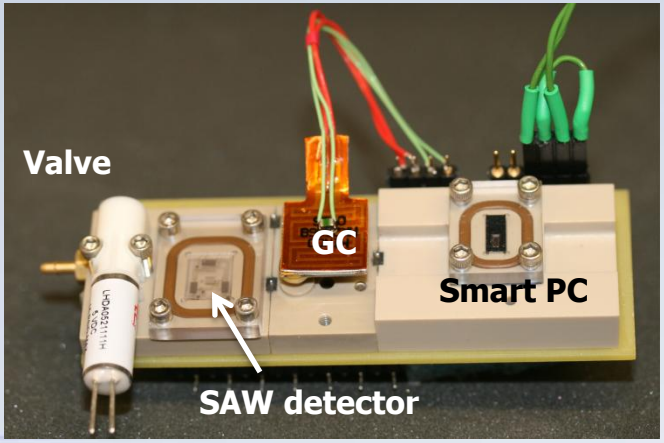
Fabrication, coating, packaging





Can be coated for VOCs

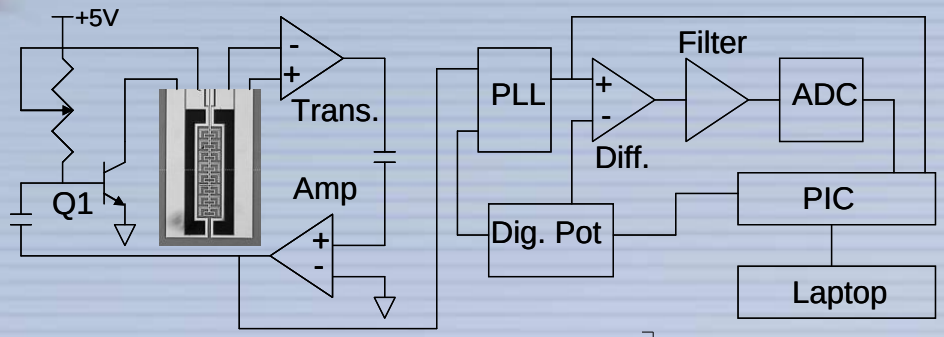




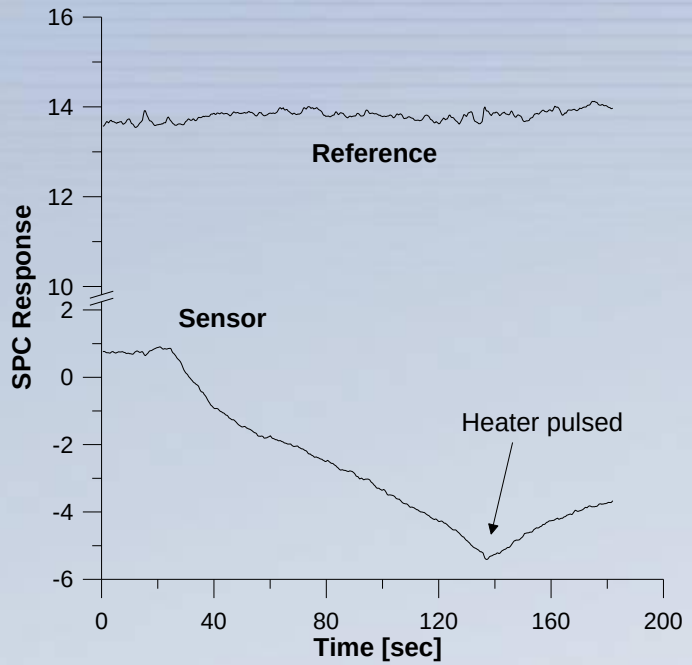
LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

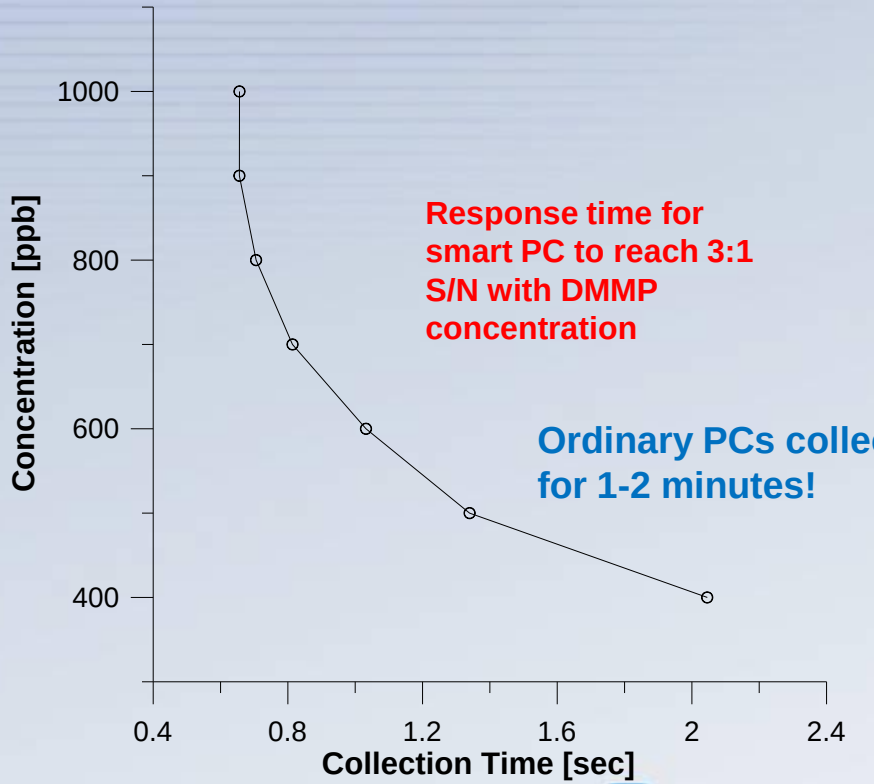
Smart PC cuts minutes off analyses and increases system dynamic range



Autotune circuit used in smart PC gas sensing. Gain goes to 11.



Smart PC response to 400 ppbv DMMP



Response time for smart PC to reach 3:1 S/N with DMMP concentration

Ordinary PCs collect for 1-2 minutes!

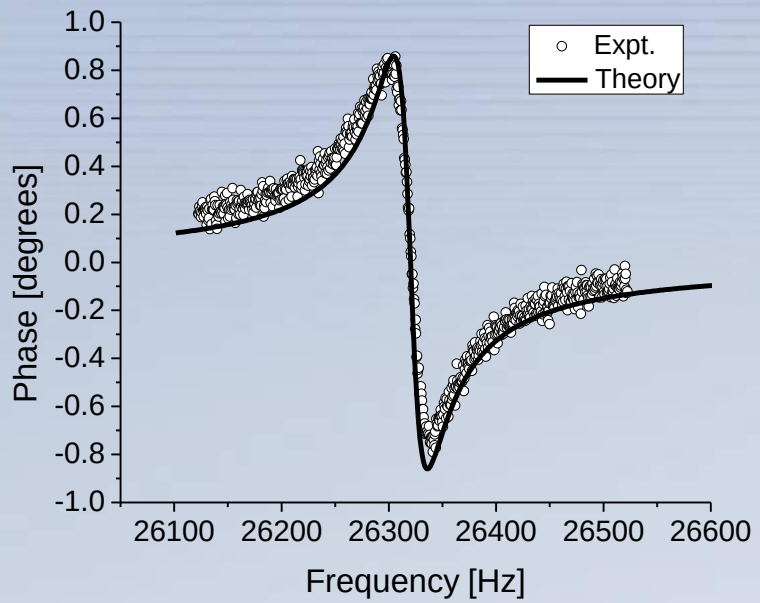
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

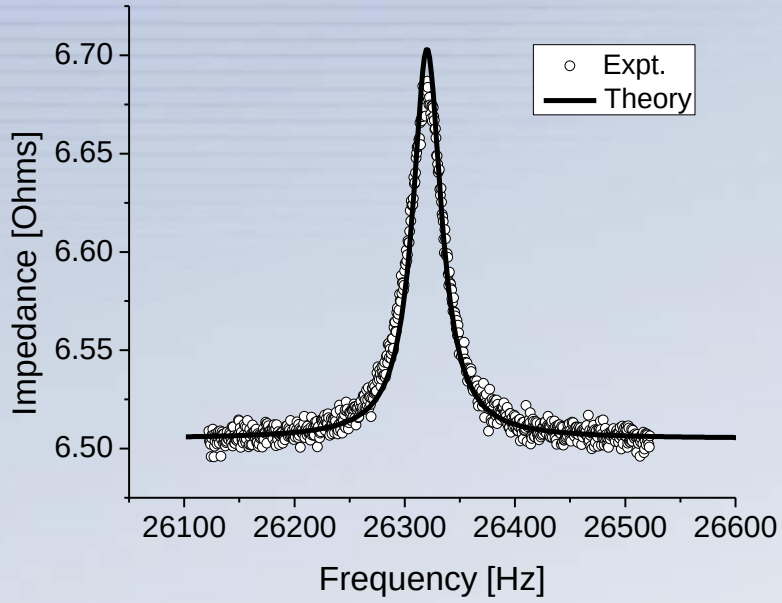
Sandia National Laboratories

Analytical theory of operation

- **Theory allows rapid optimization for new apps**

Manginell et al., *JMEMS* **17** (6) 1396-1407 (2008).





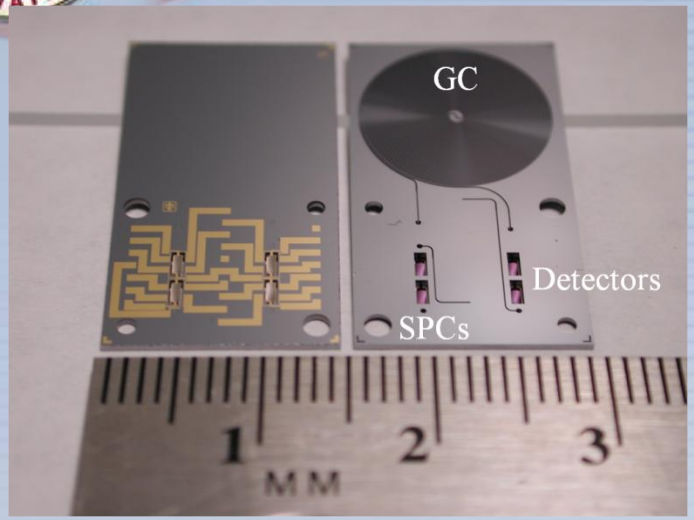
$$z = \sqrt{\left(R_o + (I_m\omega_o)^{-1} \cdot \frac{2r^2\zeta(BwL)^2}{(1-r^2)^2 + (2r\zeta)^2}\right)^2 + \left((I_m\omega_o)^{-1} \cdot \frac{(1-r^2)r(BwL)^2}{(1-r^2)^2 + (2r\zeta)^2}\right)^2}$$

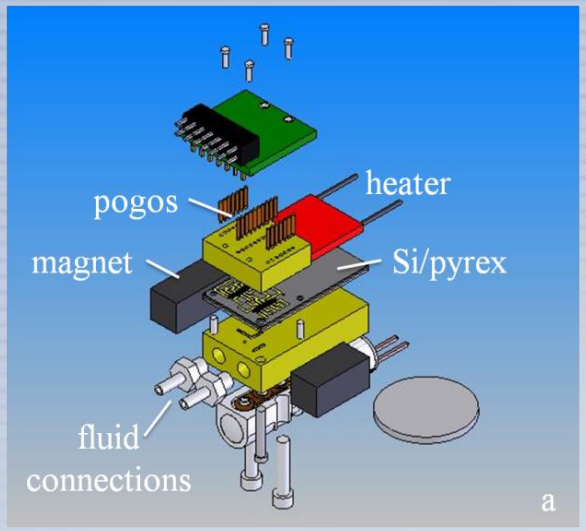
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

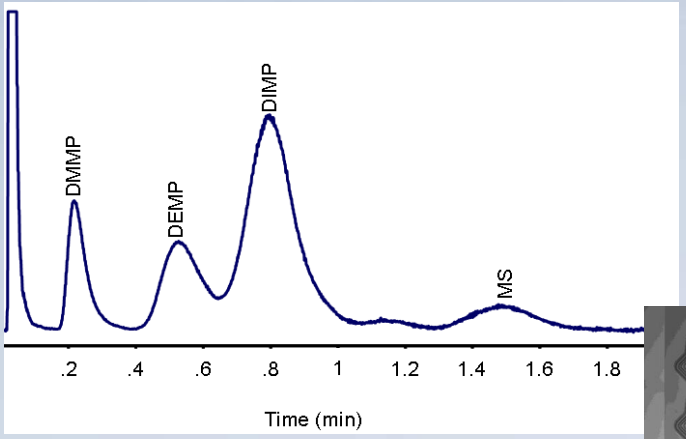
Monolithic Integration: New DARPA valves could make system even smaller

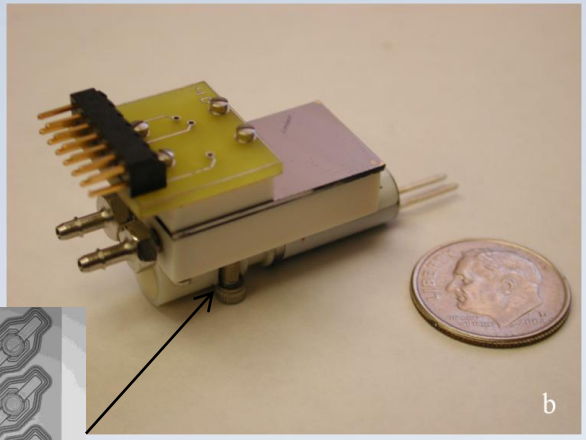
Smart PC (SPC) as PC and detector





Manginell et al., Sensors, 2011, Open Access Journal – to appear soon



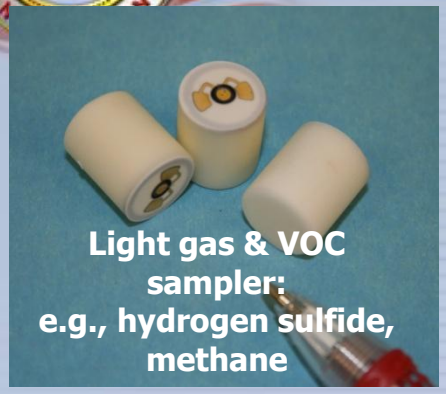


Replace Lee valve and block

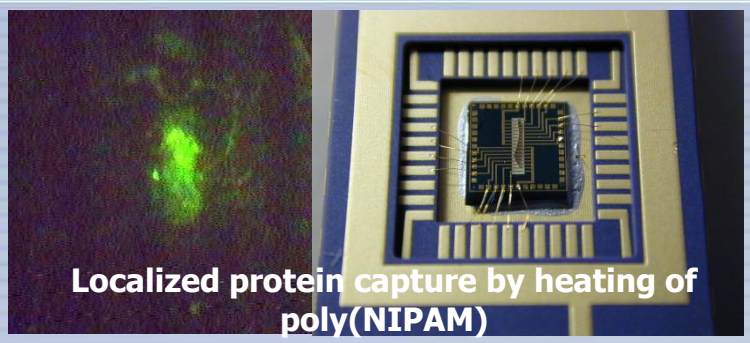
LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories

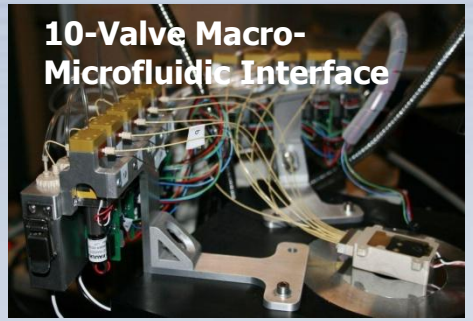
Other Devices for Chemical & Biological Detection

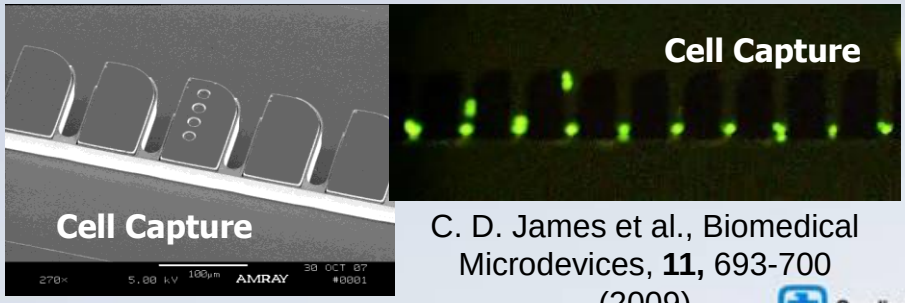


Manginell et al., accepted to Rev of Sci. Instr.



D. L. Huber et al., Science, **301**, 352-354 (2003)





C. D. James et al., Biomedical Microdevices, **11,** 693-700 (2009)

Sandia National Laboratories

Acknowledgments

- John Anderson, Matt Moorman, Rameen Hadizadeh, Pat Lewis, Doug Adkins, Davor Copic, Daniel Porter, Kent Pfeifer, Art Rumpf, Joe Simonson, Joe Bauer, James Sanchez, Susan Brozik, Achyuthan Komandoor, Curt Mowry, Dave Wheeler, Al Staton, Dale Huber, Bruce Bunker, George Bachand, Conrad James, Bryan Carson, Ron Renzi, Mike Mangan

- Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

Summary

A variety of micro and meso samplers have been developed

- Gas samplers for SVOC, VOC, light gases (H_2S, methane, etc)
- The smart PC offers very rapid warning mode operation
- Liquid systems for cell capture, FAMEs, biological preconcentration, detection

VOC ID of bacterial pathogens has been demonstrated in literature

- 3D PCs can collect VOCs effectively even with specific SVOC coatings
- Smart PCs will collect VOCs with commercial adsorbents
- New detectors (ionization) can easily detect VOCs to sub ppb levels

Integrated, portable, fast systems have been developed

- Less than 1 minute with GC separations, shorter times with smart PC
- Military, DARPA, DTRA
- Monolithic integration
- Pharmaceutical
- Water

Potential for food safety applications – and food quality

- Bacteria, mycotoxins
- Pesticides, herbicides
- Taints
- Quality of coffee, wine, beer, food
- Interested in collaboration