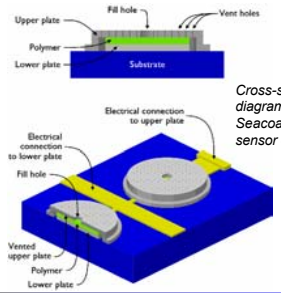
Chemicapacitive Microsensors for Chemical Detection

T.E. Mlsna, S. Cemalovic and S. V. Patel
Seacoast Science, Inc, 2151 Las Palmas, Carlsbad, CA 92009, USA
tmlsna@seacoastscience.com · tel. 760-473-8602 · www.seacoastscience.com

INTRODUCTION

Seacoast Science has been developing chemical sensors that use polymer filled micromachined capacitors to measure the dielectric constant of an array of selectively absorbing materials. Capable of detecting vapors of organic compounds and inorganic gases, each device has ten sensors on a single chip, with different coatings for redundancy and interferent rejection. Seacoast Science develops MEMS sensors for gas-phase analytes including volatile organic compounds (VOCs), chemical warfare agents (CWA), toxic industrial chemicals and materials (TICS & TIMS), emission gases and hydrogen. The compact size, low power consumption, and low cost of these sensors make them ideal for integration into varied packages for numerous applications.

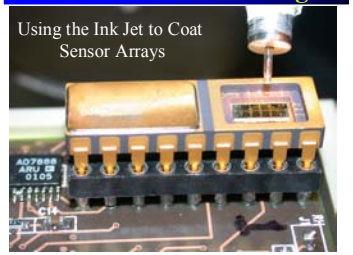
The Seacoast Science sensor has many positive features including: *1) Robustness*; our chemical sensors are extremely low mass and consequently very resistant to G-forces. *2) Low power*; our MEMS sensor elements require as little as 0.5 µW per chemicapacitor. *3) Low cost*; the microfabricated sensors can be made in large quantities at a very low cost. *4) Small size*; our MEMS sensor array is very small and dense (10 sensors on a 2 mm x 5 mm chip) allowing for a small, portable detector package (approx. 1.75 x 3 x 1 inches) *5) Selectivity*; an array of sensors with different chemoselective coatings can greatly improve sensor selectivity and sensitivity.

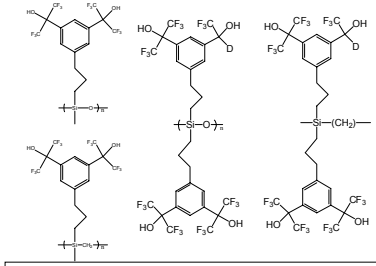


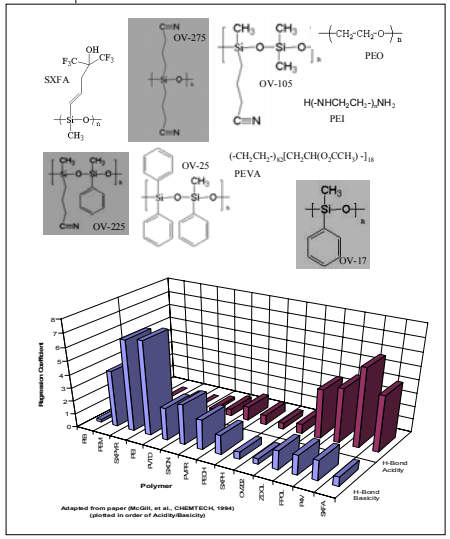
Cross-sectional diagrams of a Seacoast Science sensor element.

EXPERIMENTAL

Chemoselective Coatings

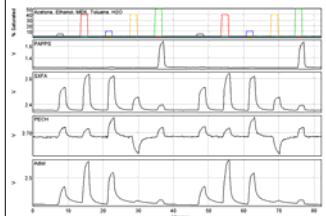




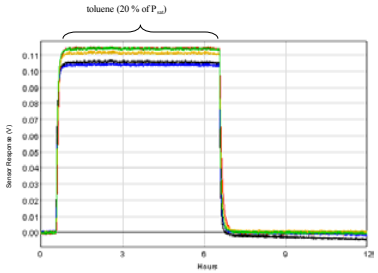


RESULTS AND CONCLUSIONS

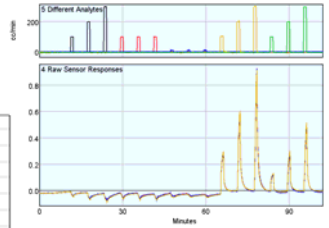
Selectivity



Stability



Reproducibility



Response Tables

Industrial Solvent	LEL	IDLH	Conc. (ppm)
Acetone	25000	2500	17
Acetonitrile	50000	500	10
Benzene	12000	500	5
Bromobenzene	5000	58	50
Ethyl acetate	20000	2000	20
Ethyl alcohol	33000	3300	12
IPA	20000	2000	18
Methyl Alcohol	60000	6000	9
Octane	14000	1000	5
Tetrahydrofuran	20000	2000	15
Toluene	11000	500	3

Live Chemical Warfare Agent	Conc. ppb
HD	970
GB	70
GA	7.2
GD	6.3

Explosive Byproduct & Taggant	Conc. (ppb)
Nitrobenzene	20
Nitropropane	5000
Nitrotoluene	1
Dinitrotoluene	20

Inorganic Gases	Conc. (ppm)
CO_2	10
HNO_3	21
NH_3	1850
ClO_2	Hg

Chemical Warfare Agent Simulant	Conc. (ppb)
CEE	200
DIMP	100
DMMP	180
Carbaryl (Pesticide)	0.3

DISCUSSION

We have shown that micromachined, parallel-plate capacitors can be filled with polymers and used to detect chemical warfare agents and toxic industrial chemicals. Chemicapacitors are uniquely selective among polymer-based VOC sensors in that they offer selectivity due to the characteristic electrical properties of the analyte in addition to the selective sorption due to the polymer/analyte interactions. This unique sensitivity of chemicapacitors to analyte permittivity can potentially lead to sensors systems with improved selectivity.

Sensors based on a single polymer are not very selective because they cannot distinguish a high concentration of a minimally-soluble interferent from a low concentration of a highly-soluble target. The selectivity of a sensor system can be enhanced by comparing the outputs either of several polymers (as in electronic noses) or of several different transducers that have varying responses to interferents and target vapors.

REFERENCES

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