CHEMICAL MICROSENSORS FOR VAPOR DETECTION

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The detection and monitoring of vapors is an important problem in such areas as process control, chemical hazard assessment, and environmental analysis. Unfortunately, many traditional solutions to the vapor monitoring problem have involved sensors which are large and expensive (e.g. IR spectrometers, Gas Chromatography/Mass Spectrometry, etc.). Thus the cost of chemical concentration information has been very high. This has resulted in a terrible bottleneck in the application of ever cheaper microcomputer technology to a vast array of process control, and environmental monitoring problems. Chemical microsensors can eliminate this bottleneck.

In their most general form, chemical microsensors consist of at least two elements: a microfabricated physical probe device and a chemically selective coating. The probe device contacts the coating and provides an electrical signal whose characteristics reflect the state of the coating. The coating is in contact with the medium in which the chemical species are to be detected. Variations in the coating properties through chemical and physical interactions, modulate the transport of matter or energy through the probe device. Work at NRL has focused on probe devices in which the transport of electrons, acoustic waves, and electromagnetic waves is modulated by chemical interactions.

The modulation of acoustic waves is accomplished using a coated Surface Acoustic Wave (SAW) delay line oscillator. Thin polymer coatings have been investigated theoretically and experimentally for their ability to selectively detect a variety of vapors. Sorption of the vapor into the coating increases the mass of the film and reduces the velocity of the Rayleigh surface wave. This is detected as a reduction of the resonant frequency of the delay line oscillator. Rapid and reversible detection of many vapors at the part per million concentration level and below has been demonstrated. A typical response of a 31 MHz SAW water vapor sensor to consecutive pulses of 5 ppm water is illustrated in figure 1.

The modulation of electronic charge transport through thin organic semiconductor films is observed with a device called a Chemiresistor. The device consists of an interdigital microelectrode array (usually gold) fabricated on an insulating substrate (usually quartz). This microelectrode is then coated with a thin organic semiconductor film. Ohmic contacts are obtained with phthalocyanine films. Interesting results have been obtained with thin sublimed films of various metal substituted phthalocyanines but the best results have been obtained form ordered multilayer films prepared by the Langmuir-

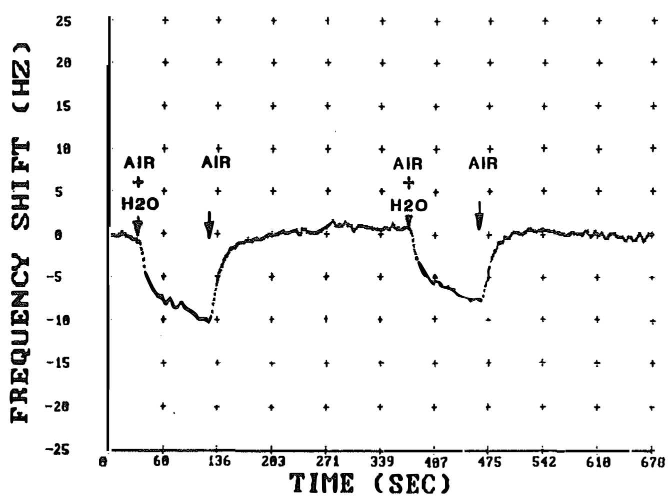

Figure 1. Typical response of a polymer coated 31 MHz SAW device exposed to consecutive pulses of 5 ppm water vapor in dry air.

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Blodgett technique. Very fast, sensitive, and reversible responses to electron donor gases are common. A typical response of a copper phthalocyanine L-B film to 2 ppm pulses of ammonia is illustrated in figure 2.

At this time the key technical challenge is to improve sensor selectivity. Efforts at NRL have emphasized chemical design, synthesis, and characterization of selective coatings, along with precise film deposition methods. The use of pattern recognition techniques with array sensors may ultimately result in a system comparable to the human nose in its ability to detect and identify vapors.

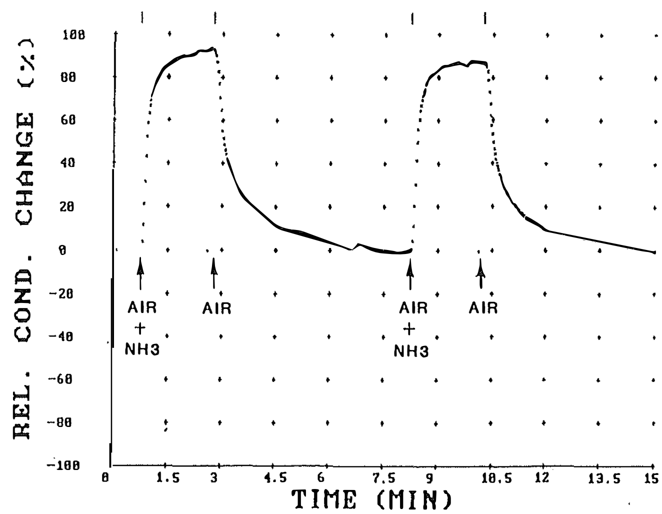

Figure 2. Response of a derivatized copper phthalocyanine multilayer film chemiresistor exposed to consecutive pulses of 2 ppm ammonia in dry air. (Starting conductance = 9×10^{-13} ohms $^{-1}$).