Multiplexed Colorimetric Solid-Phase Extraction

This analytical platform enables simultaneous determination of trace analytes in water.

Lyndon B. Johnson Space Center, Houston, Texas

Multiplexed colorimetric solid-phase extraction (MC-SPE) is an extension of colorimetric solid-phase extraction (C-SPE) — an analytical platform that combines colorimetric reagents, solid phase extraction, and diffuse reflectance spectroscopy to quantify trace analytes in water. In C-SPE, analytes are extracted and complexed on the surface of an extraction membrane impregnated with a colorimetric reagent. The analytes are then quantified directly on the membrane surface using a handheld diffuse reflectance spectrophotometer. Importantly, the use of solid-phase extraction membranes as the matrix for impregnation of the colorimetric reagents creates a concentration factor that enables the detection of low concentrations of analytes in small sample volumes.

In extending C-SPE to a multiplexed format, a filter holder that incorporates discrete analysis channels and a jig that facilitates the concurrent operation of multiple sample syringes have been designed, enabling the simultaneous determination of multiple analytes. Separate, single analyte membranes, placed in a readout cartridge create unique, analyte-specific addresses at the exit of each channel. Following sample exposure, the diffuse reflectance spectrum of each address is collected serially and the Kubelka-Munk function is used to quantify each water quality parameter via calibration curves. In a demonstration, MC-SPE was used to measure the pH of a sample and quantitate Ag(I) and Ni(II).

This work was done by Daniel B. Gazda, James S. Fritz, and Marc D. Porter of Iowa State University for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Iowa State University Research Foundation, Inc.
310 Lab of Mechanics
Ames, IA 50011-2131
Phone No.: (515) 294-4740
Fax No.: (515) 294-0778

Refer to MSC-23850-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Detecting Airborne Mercury by Use of Polymer/Carbon Films

These films can be operated and regenerated at mild temperatures.

NASA's Jet Propulsion Laboratory, Pasadena, California

Films made of certain polymer/carbon composites have been found to be potentially useful as sensing films for detecting airborne elemental mercury at concentrations on the order of tens of parts per billion or more. That is to say, when the polymer/carbon composite films are exposed to air containing mercury vapor, their electrical resistances decrease by measurable amounts. Because airborne mercury is a health hazard, it is desirable to detect it with great sensitivity, especially in enclosed environments in which there is a risk of a mercury leak from lamps or other equipment.

The present effort to develop polymer-based mercury-vapor sensors complements the work reported in *NASA Tech Briefs* "Detecting Airborne Mercury by Use of Palladium Chloride" (NPO-44955), Vol. 33, No. 7 (July 2009), page 48 and "Detecting Airborne Mercury by Use of Gold Nanowires" (NPO-44787), Vol. 33, No. 7 (July 2009), page 49. Like those previously reported efforts, the present effort is motivated partly by a need to enable operation and/or regeneration of sensors under relatively mild conditions — more specifically, at temperatures

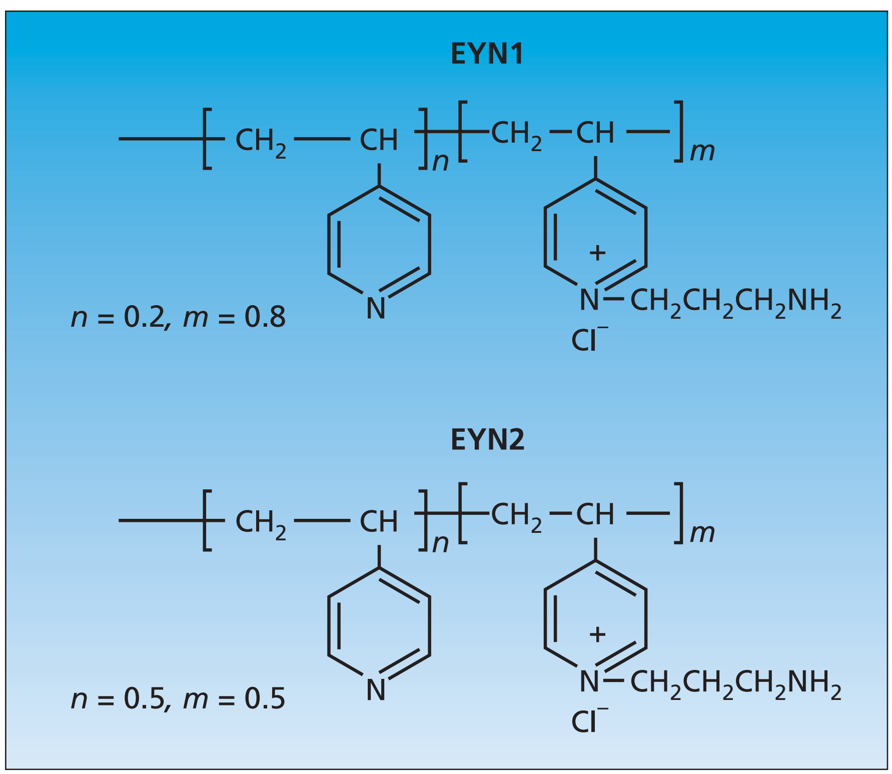

Figure 1. These **Polymers** were selected as components of mercury-detecting polymer/carbon sensor films based on quantum-mechanical computations of energies of binding between mercury atoms and polymer chemical functionalities, like these, containing amine functional group.

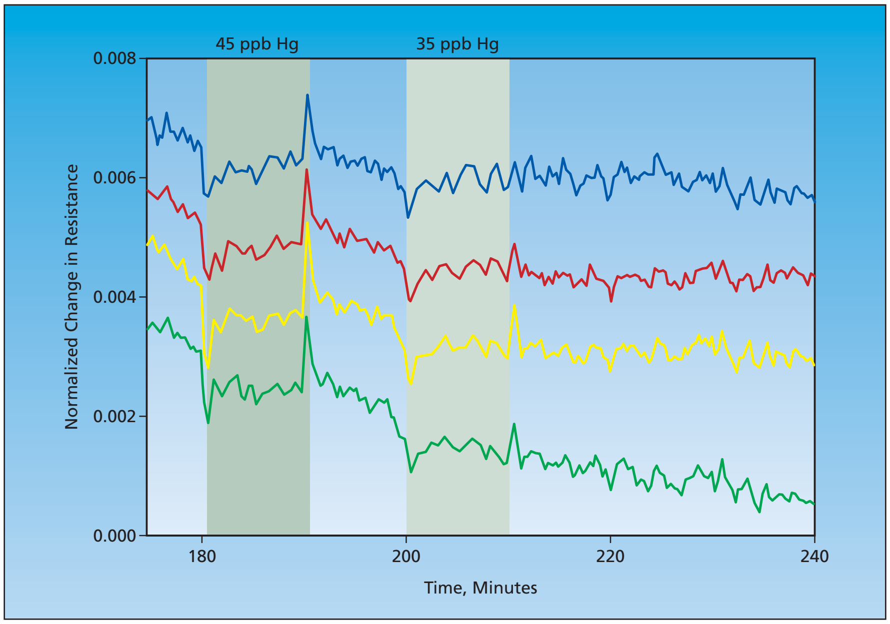

Figure 2. **Small Changes in Electrical Resistances** of four polymer/carbon composite films to airborne mercury vapor were observed at concentrations as low as tens of parts per billion.

closer to room temperature than to the elevated temperatures (>100°C) needed for regeneration of sensors based on noble-metal films.

The present polymer/carbon films are made from two polymers, denoted EYN1 and EYN2 (see Figure 1), both of which are derivatives of poly-4-vinyl pyridine with amine functional groups. Composites of these polymers with 10 to 15 weight percent of carbon were prepared and solution-deposited onto the JPL ElectronicNose sensor substrates for testing. Preliminary test results showed that the resulting sensor films gave measurable indications of airborne mercury at concentrations on the order of tens of parts per billion (ppb) or more. The operating temperature range for the sensing films was 28 to 40°C and that the sensor films regenerated spontaneously, without heating above operating temperature (see Figure 2).

This work was done by Abhijit Shevade, Margaret Ryan, Margie Homer, Adam Kisor, April Jewell, Shiao-Pin Yen, Kenneth Manatt, Mario Blanco, and William Goddard of Caltech for NASA's Jet Propulsion Laboratory.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

Innovative Technology Assets Management
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109-8099
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-45003, volume and number of this NASA Tech Briefs *issue, and the page number.*

Lattice-Matched Semiconductor Layers on Single Crystalline Sapphire Substrate

Rhombohedrally grown lattice-matched semiconductor alloys can be used in photovoltaic solar cells and photon detectors.

Langley Research Center, Hampton, Virginia

SiGe is an important semiconductor alloy for high-speed field effect transistors (FETs), high-temperature thermoelectric devices, photovoltaic solar cells, and photon detectors. The growth of SiGe layer is difficult because SiGe alloys have different lattice constants from those of the common Si wafers, which leads to a high density of defects, including dislocations, micro-twins, cracks, and delaminations.

This innovation utilizes newly developed rhombohedral epitaxy of cubic semiconductors on trigonal substrates in order to solve the lattice mismatch problem of SiGe by using trigonal single crystals like sapphire (Al_2O_3) as substrate to give a unique growth-orientation to the SiGe layer, which is automatically controlled at the interface upon sapphire (0001). This technology is different from previous silicon on insulator (SOI) or SGOI (SiGe on insulator) technologies that use amorphous SiO_2 as the growth plane.

A cubic semiconductor crystal is a special case of a rhombohedron with the inter-planar angle, $\alpha = 90°$. With a mathematical transformation, all rhombohedrons can be described by trigonal crystal lattice structures. Therefore, all cubic lattice constants and crystal planes (hkl)'s can be transformed into those of trigonal crystal parameters. These unique alignments enable a new opportunity of perfect lattice matching conditions, which can eliminate misfit dislocations. Previously, these atomic alignments were thought to be impossible or very difficult. With the invention of a new x-ray diffraction measurement method here, growth of cubic semiconductors on trigonal crystals became possible.

This epitaxy and lattice-matching condition can be applied not only to SiGe (111)/sapphire (0001) substrate relations, but also to other crystal structures and other materials, including similar crystal structures which have point-group rotational symmetries by 120° because the cubic (111) direction has 120° rotational symmetry. The use of slightly miscut (<±10°) sapphire (0001) substrate can be used to improve epitaxial relationships better by providing attractive atomic steps in the epitaxial process.

This work was done by Sang Choi and Glen King of Langley Research Center and Yeonjoon Park. Further information is contained in a TSP (see page 1). LAR-16868-1