

Effects of Temperature on Polymer/Carbon Chemical Sensors

NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments were conducted on the effects of temperature, polymer molecular weight, and carbon loading on the electrical resistances of polymer/carbon-black composite films. The experiment were performed in a continuing effort to develop such films as part of the JPL Electronic Nose (ENose), that would be used to detect, identify, and quantify parts-per-million (ppm) concentration levels of airborne chemicals in the space shuttle/space station environments. The polymers used in this study were three formulations of poly(ethylene oxide) [PEO] that had molecular weights of 20 kilodaltons, 600 kilodaltons, and 1 megadalton, respectively.

The results of one set of experiments showed a correlation between the poly-

mer molecular weight and the percolation threshold. In a second set of experiments, differences among the temperature dependences of resistance were observed for different carbon loadings; these differences could be explained by a change in the conduction mechanism.

In a third set of experiments, the responses of six different polymer/carbon composite sensors to three analytes (water vapor, methanol, methane) were measured as a function of temperature (28 to 36°C). For a given concentration of each analyte, the response of each sensor decreased with increasing temperature, in a manner different from those of the other sensors.

This work was done by Allison Manfreda, Liana Lara, April Jewell, Margie Homer,

Shiao-Pin Yen, Adam Kisor, Margaret Ryan, Hanying Zhou, Abhijit Shevade, and Lim James of Caltech and Kenneth Manatt of Santa Barbara Applied Research 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

(818) 354-2240

E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-40621, volume and number of this NASA Tech Briefs issue, and the page number.

Small CO₂ Sensors Operate at Lower Temperature

Lower operating temperature translates to lower power demand.

John H. Glenn Research Center, Cleveland, Ohio

Solid-electrolyte-based amperometric sensors for measuring concentrations of CO₂ in air are being developed for use in detection of fires, environmental monitoring, and other applications where liquid-based electrochemical cells are problematic. These sensors are small (sizes of the order of a millimeter), are robust, are amenable to batch fabrication at relatively low cost, and exhibit short response times (seconds) and wide detection ranges.

A sensor of this type at a previous stage of development included a solid electrolyte of Na₃Zr₂Si₂PO₁₂ deposited mainly between interdigitated Pt electrodes on an alumina substrate, all overcoated with an auxiliary solid electrolyte of (Na₂CO₃:BaCO₃ in a molar ratio of 1:1.7). It was necessary to heat this device to a temperature as high as 600 °C to obtain the desired sensitivity and rapid response. Heating sensors increases the power consumption of the sensor system and complicates the use of the sensor in some applications. Thus, decreasing a sensor's power consumption while maintaining its performance is a technical goal of ongoing development.

A sensor of this type at the present state of development (see Figure 1) has

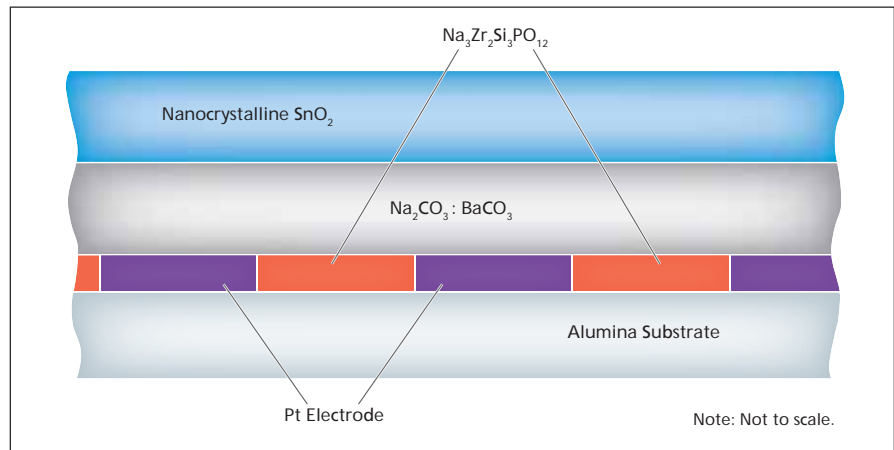


Figure 1. The Layer of Nanocrystalline SnO₂ enhances the function of the solid-electrolyte layers of Na₃Zr₂Si₂PO₁₂ and Na₂CO₃:BaCO₃, making it possible to operate at a lower temperature.

the same basic structure, except that it includes an additional outer layer of nanocrystalline SnO₂, which is an n-type (electron-donor-type) semiconductor that provides additional electrons for reduction reaction at the working electrode to detect CO₂. [This use of SnO₂ as a CO₂-sensor material should not be confused with the use of SnO₂ in a related development described in "CO₂ Sensors Based on Nanocrystalline SnO₂ Doped With CuO" (LEW-18247-1), NASA Tech Briefs, Vol 32, No. 10 (October 2008), page 44. The SnO₂ layer

makes it possible to obtain the desired sensor responses at a lower temperature (355 °C), thereby making it possible to operate the sensor at lower power. Figure 2 shows the comparison in response between a sensor with and without the armor layer of nanocrystalline SnO₂. Concentrations of CO₂ from 0.5 to 4% in air were also detected at 375 °C.

A sensor of this type can be fabricated in the following sequence:

1. The platinum interdigitated electrodes, typically having width and spacing of 30 μm, are formed on the