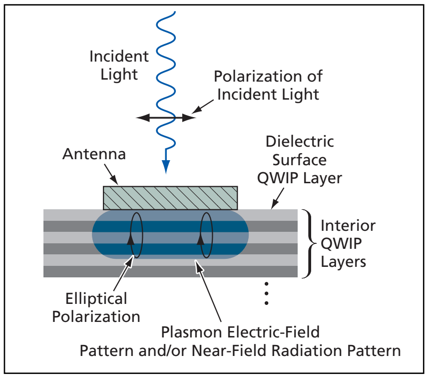

A **Surface Plasmon** with elliptical polarization would form under the antenna. The perpendicular component of the elliptical polarization would enable absorption of the incident light.

gles, thereby imparting some perpendicular polarization. Unfortunately, the corrugation-fabrication process increases the overall nonuniformity of a large QWIP array. The proposed scheme is an alternative to the use of surface corrugations.

For a given QWIP, the metal and the size and shape of the antenna would be chosen so that the combination of the antenna and the adjacent surface dielectric layer of the QWIP would support surface plasmon states at wavelengths of interest. The interface between a dielectric and a metal can support a surface electromagnetic wave if the permittivity of the metal, expressed as a complex number, has a negative real component. The distribution of amplitude in a plasmon peaks at the metal/dielectric interface and decays exponentially with distance from the interface into the metal or the dielectric.

In cases relevant to the proposal, the polarization states of the electric field are elliptical, characterized by major axes parallel to the interface on the metal side and perpendicular to the interface in the dielectric side. The contribution of the surface-plasmon effect to perpendicular polarization would be augmented by the contribution of strong perpendicular-polarization components of the near field of the antenna. Presumably, designs could also be optimized to obtain resonant or broadband antenna structures to maximize coupling of light from free space into perpendicularly polarized plasmon modes.

This work was done by John Hong 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
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-43681, volume and number of this NASA Tech Briefs *issue, and the page number.*

Electronic Tongue Containing Redox and Conductivity Sensors

Progress has been made toward long-lived sensors for monitoring water quality.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electronic tongue 2 (E-tongue 2) represents the second generation of the apparatus described in "Electronic Tongue for Quantitation of Contaminants in Water" (NPO-30601), *NASA Tech Briefs*, Vol. 28, No. 2 (February 2004), page 31. To recapitulate: The previously reported apparatus, now retrospectively denoted E-tongue 1, is an assembly of sensors for measuring concentrations of metal ions and possibly other contaminants in water. Potential uses for electronic tongues include monitoring the chemical quality of water in a variety of natural, industrial, and laboratory settings, and detecting micro-organisms indirectly by measuring microbially influenced corrosion.

E-tongue 2 includes a heater, a temperature sensor, an oxidation/reduction (redox) sensor pair, an electrical sensor, an array of eight galvanic cells, and eight ion-specific electrodes. These devices are formed in a substantially planar configuration on an alumina substrate 1 mm thick and 1.3 in. (3.3 cm) in diameter (see Figure 1). The fabrication process includes screen printing of the components of the aforementioned devices on the front side of the substrate, laser drilling of via holes for electrical contacts with wires

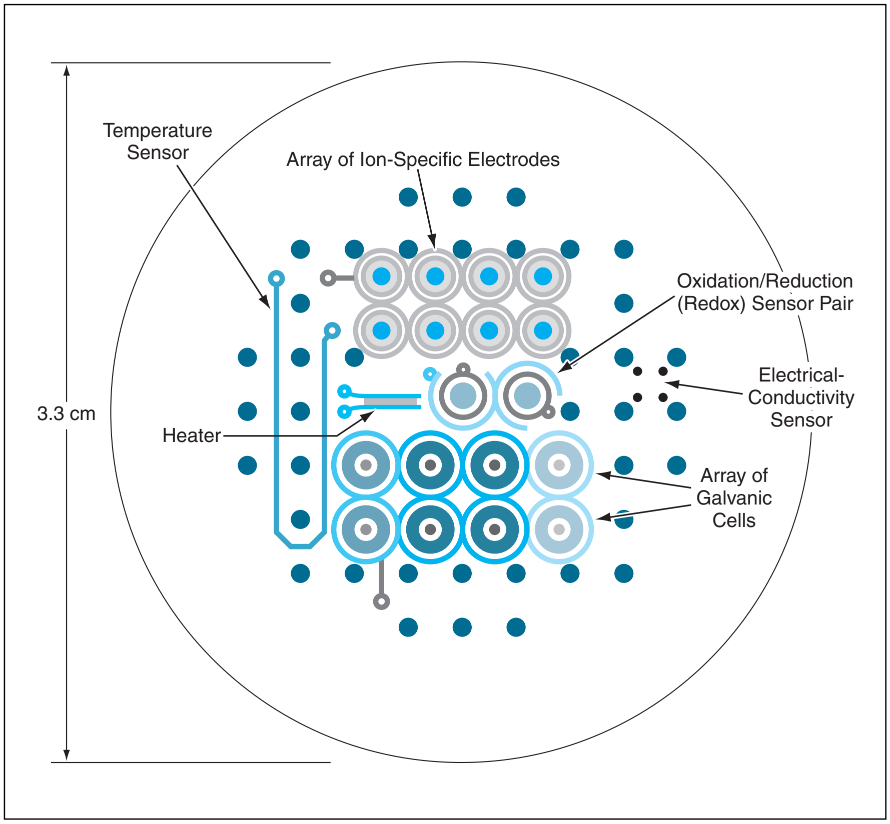

Figure 1. The **Layout of E-Tongue 2** is nearly identical to the layout of E-tongue 1, depicted in an earlier *NASA Tech Briefs* article.

screen-printed on the back side of the substrate, rendering the vias conductive by drawing screen-print material through them using partial vacuum on one side, adding pins for connection to external circuitry, and firing the printed substrate in air at high temperature.

An important aspect of the planar configuration is that the counter electrodes of all the cells in the array are integral parts of a grounded common conductor on the front surface of the substrate. The use of this common conductor helps to minimize the number of wires and pins and facilitates miniaturization of the array. The common conductor also serves as a ground plane that suppresses electric-field interference among the cells in the array.

The planarity of the array facilitates cleaning of the array by a number of techniques, including wiping, exposure to ultraviolet light, and electrolytic generation of hydrogen and oxygen. The planar configuration also facilitates the reservation of some cells and sensors as spares. The cleaning and sparing are intended to enable extension of the life of the E-tongue. Yet other advantages of the planar configuration are that it facilitates incorporation of the E-tongue into a flow-through cell and is amenable to microscopic observations.

The progression from E-tongue 1 to E-tongue 2 has involved improvements in design, operation, interpretation of sensor readings, and understanding of the underlying chemical and physical mechanisms, all directed toward development of large arrays of robust, long-lived sensors for monitoring water quality. There has been particular emphasis on the redox sensors, which are based on a traditional electrochemical cell used for making pH and other ionic-content measurements. Such a cell includes a working electrode, a reference electrode, and a counter electrode. However, whereas the electrodes in a traditional cell have a pencillike configuration, the electrodes in each redox sensor of the E-tongue are planar and concentric (see Figure 2) and their counter electrodes are integral parts of the ground plane.

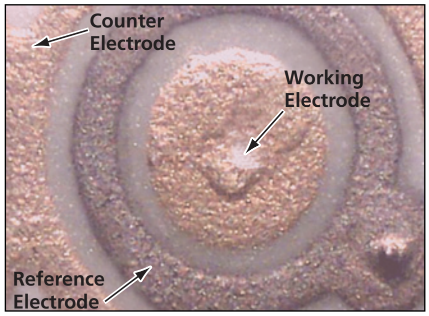

Figure 2. **One of the Redox Sensors** is shown here magnified. The working and counter electrodes are made of a platinum/gold alloy; the reference electrode is made of silver/palladium alloy. The inner diameter of the counter electrode is 2.75 mm.

Excitation and readout circuitry has been designed and constructed specifically for use in operating the E-tongue. In operation, the currents flowing to and from the electrodes of the electrochemical cells and an adjacent electrical-conductivity sensor on the E-tongue are measured as the voltages applied to the electrodes are scanned through appropriate ranges, called detection windows. The measurement data are then processed and interpreted to detect and quantitate ions in solution. The detection windows are bounded by electrolytic generation of hydrogen at negative potentials and oxygen at positive potentials. In the case of the redox sensors of E-nose 2, the window is between –2 and +1 V.

This work was done by Martin Buehler 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
(818) 354-2240
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-30862, volume and number of this NASA Tech Briefs *issue, and the page number.*