



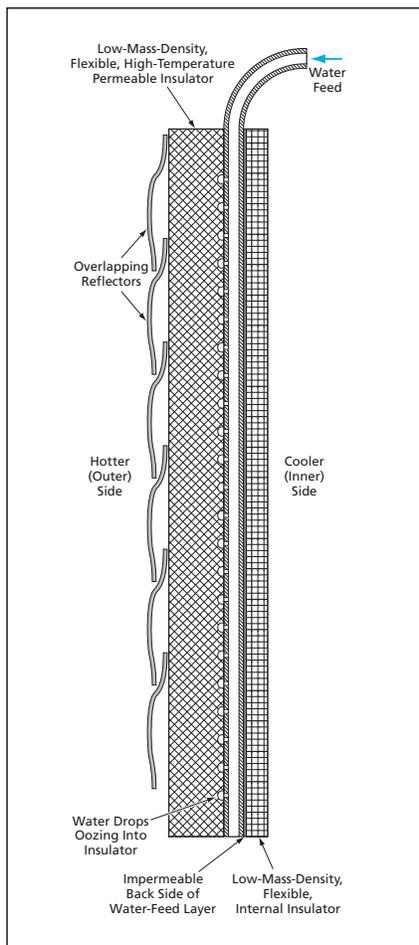
## Evaporation-Cooled Protective Suits for Firefighters

In comparison with suits now in use, these could protect for longer times.

Langley Research Center, Hampton, Virginia

Suits cooled by evaporation of water have been proposed as improved means of temporary protection against high temperatures near fires. When air temperature exceeds 600 °F (316 °C) or in the presence of radiative heating from nearby sources at temperatures of 1,200 °F (649 °C) or more, outer suits now used by firefighters afford protection for only a few seconds. The proposed suits would exploit the high latent heat of vaporization of water to satisfy a need to protect against higher air temperatures and against radiant heating for significantly longer times. These suits would be fabricated and operated in conjunction with breathing and cooling systems like those with which firefighting suits are now equipped.

A protective suit according to the proposal would include a water-storage and -distribution system that would cause the suit to “sweat” all over as needed. The quantity of water carried (typically a few liters) could be selected according to the expected task. If the water were carried in a slightly pressurized tank, there would be no need for a pump. The water-distribution system would include bimetallic-actuated valves that would regulate rates of flow according to the local temperatures in the suit. For example, it has been estimated that releasing water at a rate of 1 milliliter per second would be sufficient to prevent the surface temperature of the suit from exceeding 140 °F (60 °C) at an air temperature of 1,000 °F (538 °C), and a 2-liter supply of water would be more



**Shinglelike Outer Reflectors** would protect against radiative heating. Evaporation of water from the inner surface of a permeable insulating layer would keep the interior temperature much lower than the ambient air temperature.

than enough to provide this protection for half an hour. The adjustability of flow rates would also make it possible to protect against radiative heating for times longer than were previously possible.

For even better protection against both conductive and radiative heating, a suit according to the present proposal could include both a highly reflective outer layer as well as an evaporative-cooling sublayer system. Whereas the outer layers of some protective suits now in use have reflectivities of about 0.90, the proposal calls for a reflectivity of about 0.97. In one version, shown in the figure, the outer layer would consist of overlapping shinglelike reflectors (see figure), possibly made of thin copper plates coated with gold. The shingles would be individually attached to the suit so that they could slide over each other and motion would not be restricted. The water would be injected into, and would evaporate from the inner surface of a thick, permeable insulating layer, which is shielded by the reflective shingles. The shingles would be allowed to get very hot, but the wet sub-layer would remain much cooler, and water would be used up at a lower rate than would be the case if no reflective shingles were used and water were allowed to evaporate directly from a hot outer surface.

*This work was done by Leonard Murray Weinstein of Langley Research Center. For further information, contact the Langley Innovative Partnerships Office at (757) 864-8881. LAR-16245-1*

## Plasmonic Antenna Coupling for QWIPs

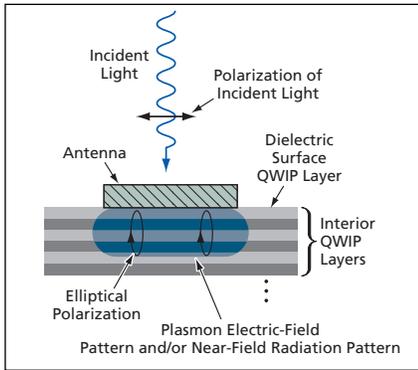
Plasmonic antennas would be potentially superior alternatives to surface corrugations.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a proposed scheme for coupling light into a quantum-well infrared photodetector (QWIP), an antenna or an array of antennas made of a suitable metal would be fabricated on the face of what would otherwise be a standard QWIP (see figure). This

or any such coupling scheme is required to effect polarization conversion: Light incident perpendicularly to the face is necessarily polarized in the plane of the face, whereas, as a matter of fundamental electrodynamics and related quantum selec-

tion rules, light must have a non-zero component of perpendicular polarization in order to be absorbed in the photodetection process. In a prior coupling scheme, gratings in the form of surface corrugations diffract normally incident light to oblique an-



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.*

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## 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

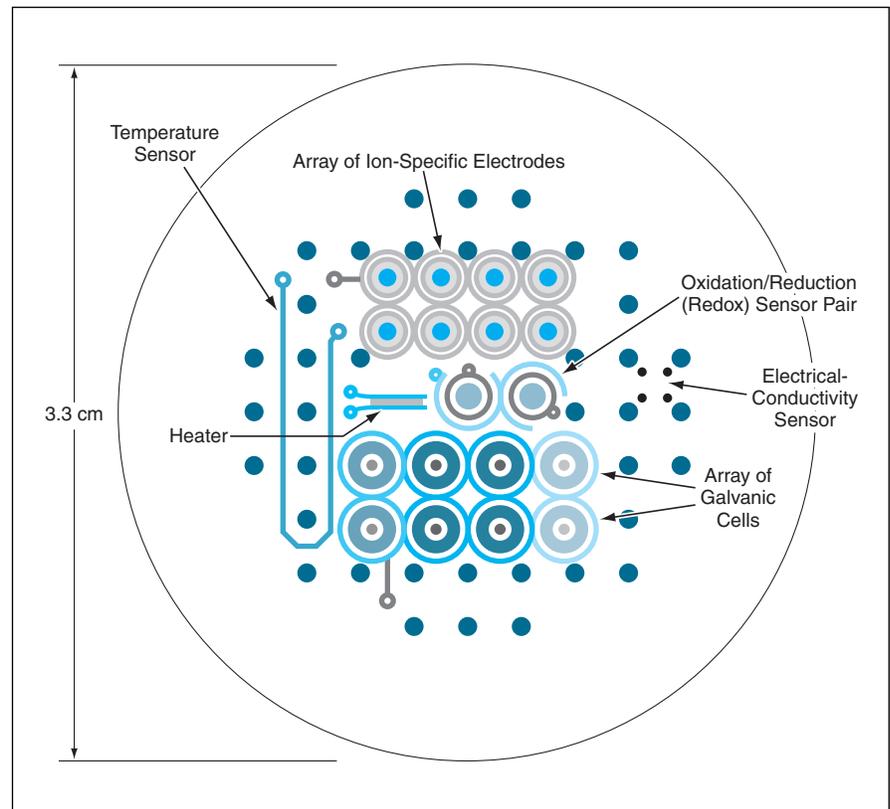


Figure 1. The **Layout of E-Tongue 2** is nearly identical to the layout of E-tongue 1, depicted in an earlier *NASA Tech Briefs* article.