measurement data are processed by a radiative-transfer computer code to estimate spectral radiances at the position of a sensor known to be overhead at the time of the measurements. These radiances can be compared with the sensor readings to calibrate the sensor.

Previously, in order to perform vicarious calibration, it was necessary to dispatch field teams on expensive measurement campaigns to target sites, scheduled in accordance with sensor overpass times and weather conditions. Difficulty was compounded by remoteness and limited accessibility of typical targets. The present ground facility nearly eliminates the need for field measurement campaigns by acquiring data nearly continuously and making the data available to all interested parties via the World Wide Web.

The present ground facility occupies a target site consisting of the Frenchman Flat dry lakebed located northnortheast of Mercury, Nevada. The instrumentation at the facility includes a light-emitting-diode spectrometer (LSpec), which consists of eight tripodmounted, ground-viewing radiometer units containing LEDs biased to operate as photodetectors (instead of light emitters) at their respective wavelengths. The LSpec provides an essentially continuous stream of measurements at eight discrete wavelengths. These are merged with spectral surface-reflectance measurements made on occasional site visits to obtain temporally continuous coverage with high spectral resolution. Other equipment at the site includes a weather station and a tracking sunphotometer (see figure).

Measurement data are acquired at intervals of 5 minutes under all daylight conditions. The data are entered into a database maintained on a Jet Propulsion Laboratory server computer. A remote user can log into a Web-based interface and request information specific to the overpass time of a given sensor. The data can be fed as input to the radiative-transfer computer program to obtain radiances for calibration of the sensor.

This work was done by Carol Bruegge and Shannon Jackson of Caltech and Mark Helmlinger of Northrop Grumman Space Technology for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-45425

Optical Pressure-Temperature Sensor for a Combustion Chamber
This compact sensor would withstand the harsh combustion environment.

Marshall Space Flight Center, Alabama

A compact sensor for measuring temperature and pressure in a combustion chamber has been proposed. Heretofore, independent measurements of high pressures and temperatures in combustion chambers have not been performed. In the original intended application, the combustion chamber would be that of a rocket engine. Sensors like this one could also be used to measure temperatures and pressures in other combustion chambers and other, similar harsh settings. There could be numerous potential applications in the aeronautical and automotive industries.

In the original rocket-engine application, accurate measurements of pressure and temperature are needed for feedback control to suppress combustion instability. Heretofore, none of the avail-

able pressure sensors have been capable of surviving the thermal environment of a combustion chamber without the use of sensing lines or helium-filled cavities. Pressure-measurement signals obtained by use of sensing lines or helium-filled cavities have altered power spectra that make the signals unsuitable as feedback signals for control purposes.

The proposed sensor would include two optically birefringent, transmissive crystalline wedges: one of sapphire (Al_2O_3) and one of magnesium oxide (MgO), the optical properties of both of which vary with temperature and pressure. The wedges would be separated by a vapor-deposited thin-film transducer, which would be primarily temperature-sensitive (in contradistinction to pressure-sensitive) when attached to a crys-

talline substrate. The sensor would be housed in a rugged probe to survive the extreme temperatures and pressures in a combustion chamber. An externally generated optical input signal would travel through parts of the wedges. The effect of the thin-film transducer on the propagating light beam would provide temperature information. The effect of stress-induced birefringence in the crystalline wedges upon the light beam would provide pressure information.

This work was done by John Wiley of Marshall Space Flight Center, Valentin Korman of Madison Research Corp., and Don Gregory of the University of Alabama in Huntsville. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32075-1.
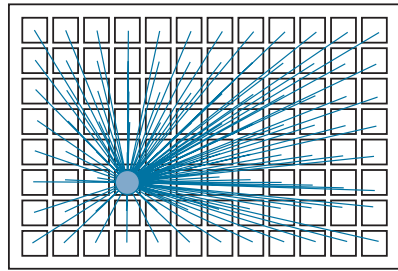
Impact-Locator Sensor Panels
Panels can be electronically daisy-chained and assembled to cover large areas.

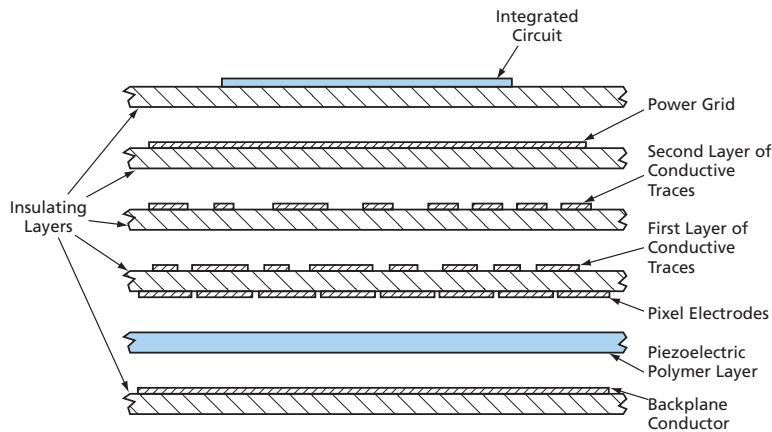*Lyndon B. Johnson Space Center, Houston, Texas*

Electronic sensor systems for detecting and locating impacts of rapidly moving particles on spacecraft have been invented. Systems of this type could also be useful on Earth in settings in which the occurrence of impacts and/or the

locations of impacts are not immediately obvious and there are requirements to detect and quickly locate impacts to prevent or minimize damage. For example, occupants of a military vehicle could know immediately that

someone was shooting at it and which side of the vehicle was taking fire. For another example, commercial transportation companies using these systems for remote monitoring of valuable cargo could know when and from what

**PLAN VIEW SHOWING PIXELS AND CONDUCTIVE TRACES
BETWEEN PIXELS AND INTEGRATED CIRCUIT**

**MAGNIFIED, ELPLODED CROSS-SECTIONAL VIEW WITH THICKNESSES
GREATLY EXAGGERATED AND NOT TO SCALE**

A **Typical Sensor Panel** comprises multiple layers of electronic circuitry and a piezoelectric polymer film.

direction impacts were jeopardizing the cargo, whether the impacts were from hailstones, burglary tools, vehicular collisions, or firearms.

The building blocks of a system of this type are sensor panels. Each panel is a thin multilayer structure wherein one of the layers is a commercially available film of poly(vinylidene fluoride) [PVDF], which is a piezoelectric polymer. Because of its piezoelectricity, the film generates an electric potential at the place and time of an impact. Electronic circuitry that is part of the multilayer structure (as described below) detects this potential, thereby detecting the impact. The panels are constructed identically and can have any convenient dimensions; a width of 16 in. (≈0.4 m) and a length of 24 in. (≈0.6 m) are typical. Multiple panels can be joined to cover an area as large as required.

The electronic circuitry includes electrodes and conductive traces, on the surfaces of the PVDF film (see figure), that subdivide the panel into pixels within which impacts can be located. Typical pixel dimensions are 2 by 2 in. (about 5 by 5 cm), but pixels could just as well be made larger or smaller as needed. Optionally, the PVDF film could also be scribed into pixels to enhance spatial resolution.

The conductive traces connect the pixel electrodes to an integrated circuit (typically either a field-programmable gate array or an application-specific integrated circuit) on the panel. The integrated circuit detects any impact signals, determines the pixel locations of the signals, determines the pixel location of the first signal, and stores these pixel locations in registers. The integrated circuit then generates a data-transmission word that includes all the pixel impact locations, the first-impact pixel location, and an address unique to the panel. The word is transmitted to an external digital-processor-and-display unit, which could be, for example, a laptop computer. The transmission is fundamentally a notice to the external unit that an impact has been detected at the noted location on the noted panel.

Each panel is connected to external circuits via only two wires, which serve for transmission of both data and power. Wires can be daisy-chained through as many panels as desired, so that only two wires are needed to make the external connections to an assembly of any number of panels. It is not necessary to supply power to operate the piezoelectric transducers; the only power that must be supplied is that required for operation of the integrated circuits on the panels and of the external digital-processor-and-display unit. Hence, the overall power demand of the system is relatively small.