Technology Focus: Sensors

Energy-Based Tetrahedron Sensor for High-Temperature, High-Pressure Environments

This sensor is applicable in the mining industry or in acoustic applications where energy-based measurements are required.

Stennis Space Center, Mississippi

An acoustic energy-based probe has been developed that incorporates multiple acoustic sensing elements in order to obtain the acoustic pressure and three-dimensional acoustic particle velocity. With these quantities, the user can obtain various energy-based quantities, including acoustic energy density, acoustic intensity, and acoustic impedance. In this specific development, the probe has been designed to operate in an environment characterized by high temperatures and high pressures as is found in the close vicinity of rocket plumes. Given these capabilities, the probe is designed to be used to investigate the acoustic conditions within the plume of a rocket engine or jet engine to facilitate greater understanding of the noise generation mechanisms in those plumes.

The probe features sensors mounted inside a solid sphere. The associated electronics for the probe are contained within the sphere and the associated handle for the probe. More importantly, the design of the probe has desirable properties that reduce the bias errors associated with determining the acoustic pressure and velocity using finite sum and difference techniques. The diameter of the probe dictates the lower and upper operating frequencies for the probe, where accurate measurements can be acquired. The current probe design implements a sphere diameter of 1 in. (2.5 cm), which limits the upper operating frequency to about 4.5 kHz. The sensors are operational up to much higher frequencies, and could be used to acquire pressure data at higher frequencies, but the energy-based measurements are limited to that upper frequency. Larger or smaller spherical probes could be designed to go to lower or higher frequency ranges.

The probe was manufactured using four G.R.A.S 40 BH 1/4" microphones embedded in the 1-in. (2.5-cm) sphere. The pre-amplifiers for the microphones are also embedded in the sphere. These microphones are capable of operation in sound fields up to 190 dB, which make them suitable for the rocket plume environment. The LabVIEW data acquisition system acquires the microphone signals from each of the four probes and estimates the acoustic pressure at the center of the probe as the average of the four measured pressures. The acoustic particle velocity is obtained using finite difference techniques to acquire a velocity estimate between each pair of microphones in the tetrahedron design. These six particle velocity estimates are along different directions and estimate the particle velocity at the center point of that side of the tetrahedron. Thus, the user is required to determine the three orthogonal velocity components from these six estimates made. The advantage of using an energy-based probe is that it allows the user to extract additional information regarding the radiation characteristics of the source being investigated.

This work was done by Kent L. Gee, Scott D. Sommerfeldt, and Jonathan D. Blotter of Brigham Young University for Stennis Space Center. For more information, contact the SSC Chief Technologist Office at (228) 688-1929. Refer to SSC-00355.

Handheld Universal Diagnostic Sensor

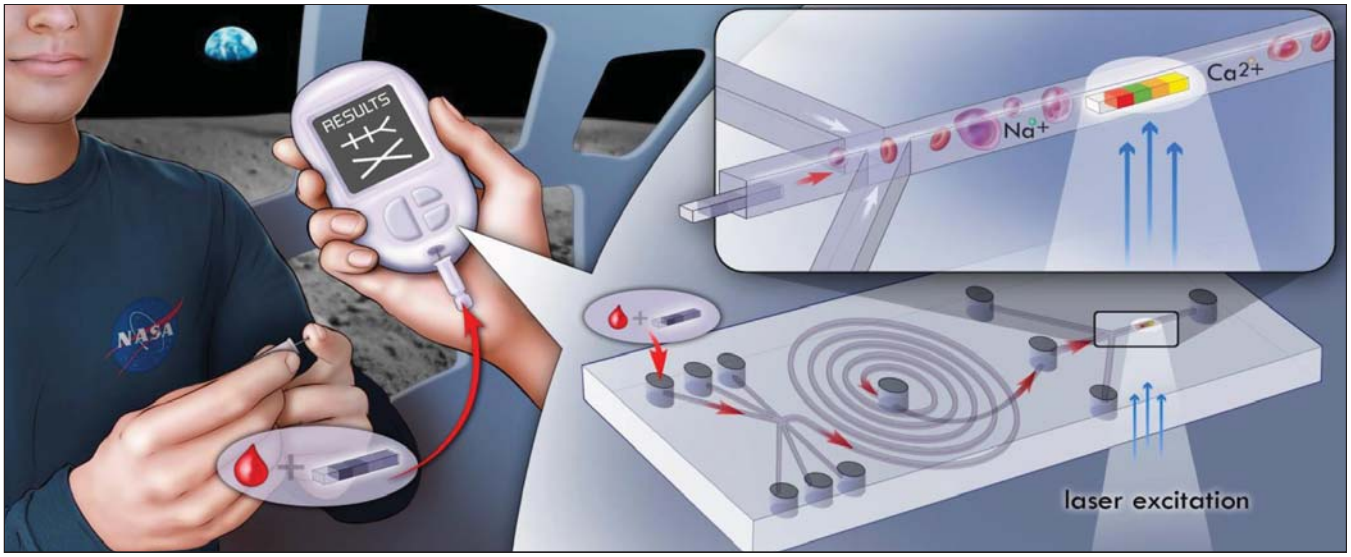
A single drop of blood enables chemistry, hematology, and biomarker diagnostics in minutes.

John H. Glenn Research Center, Cleveland, Ohio

The rHEALTH technology is designed to shrink an entire hospital testing laboratory onto a handheld device. A physician or healthcare provider performs the test by collecting a fingerstick of blood from a patient. The tiny volume of blood is inserted into the rHEALTH device (see figure). Inside the device is a microfluidic chip that contains small channels about the width of a human hair. These channels help move the blood and analyze the blood sample. The rHEALTH sensor uses proprietary reagents called nanostrips, which are nanoscale test strips that enable the clinical assays. The readout is performed by laser-induced fluorescence. Overall, the time from blood collection through analysis is less than a minute.

The spiral-shaped microfluidic channels perform all the necessary sample preprocessing required for sample analysis. They accomplish this by mixing and diluting the blood sample in a miniaturized geometry. In contrast, for typical benchtop blood counters and clinical analyzers, these steps require automation and large amounts of reagents. Performing these steps on-chip allows these tests to be applicable for point-of-care settings. Furthermore, for reliable results, the on-chip processing steps are all compatible with the chips' flow-through geometry, which prevents blood stasis and clotting.

The rHEALTH prototype sensor is small, rugged, and fits in the palm of a hand. It uses state-of-the-art solid-state lasers and detectors that allow for robust, time-of-flight analysis of the samples. The performance remains uncompromised, al-



rHEALTH Universal Blood Sensor is designed to perform a breadth of analyses on blood or bodily fluids.

lowing high-sensitivity fluorescence analysis. Traditional flow cytometric profiles are obtained using this device. These include intensity versus intensity scatterplots and cell histograms. Flow-based, laser-induced fluorescence is thus a powerful technique that allows the user to have a universal detection platform for all of the assays, whether they be antibody, nanostrip, hematology, or biomarker assays. The microfluidic system allows a wide range of reagents, including antibodies, fluorescent dyes, and proprietary nanoscale test strips to be mixed with the blood sample. Typical existing commercial sensors can only perform one test at a time.

The rHEALTH device employs sophisticated flow-based detection technologies that allow a wide range of samples to be counted, analyzed, and measured with a high degree of multiplexing. The sensor is able to perform a range of analyses for cells, electrolytes, biomarkers, nucleic acids, and small molecules on a blood sample smaller than 10 µL.

This work was done by Eugene Chan of DNA Medicine Institute, Inc. for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18727-1.

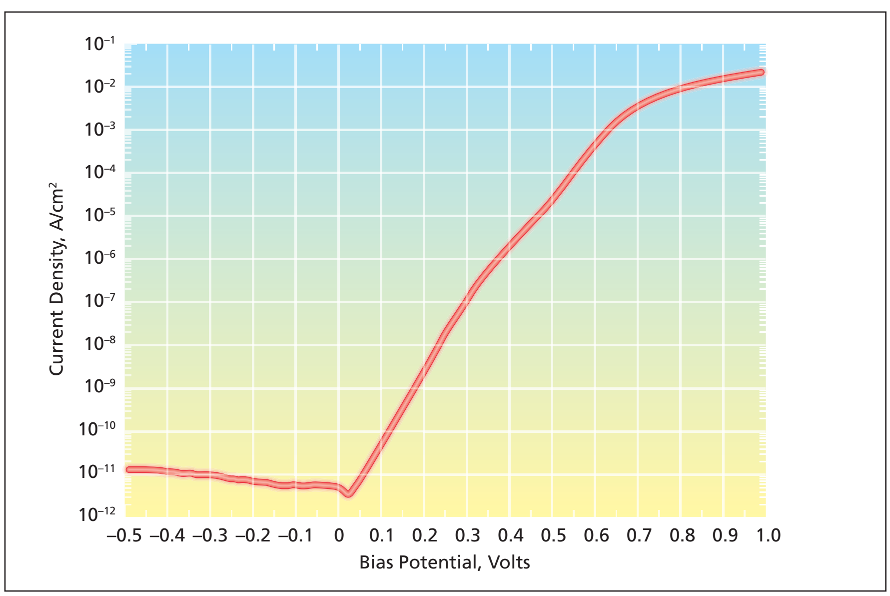
Large-Area Vacuum Ultraviolet Sensors

These devices exhibit very low dark currents.

Goddard Space Flight Center, Greenbelt, Maryland

Pt/(n-doped GaN) Schottky-barrier diodes having active areas as large as 1 cm square have been designed and fabricated as prototypes of photodetectors for the vacuum ultraviolet portion (wavelengths ≈200 nm) of the solar spectrum. In addition to having adequate sensitivity to photons in this wavelength range, these photodetectors are required to be insensitive to visible and infrared components of sunlight and to have relatively low levels of dark current.

In preparation for fabricating a batch of assorted prototype detectors, a c-plane (0001-plane) sapphire wafer was subjected to a rigorous cleaning by use of an acid and an organic solvent. Fabrication began with low-pressure metalorganic vapor-phase epitaxy of four GaN layers on the sapphire wafer: The first was a 25-nm-thick GaN nucleation layer. The second was a thicker GaN buffer



Current Density vs. Voltage was determined from measurements on device of the type described in the text.