

Testing involved a small, metal Dewar tank composed of an inner and outer shell. The annular region was filled with perlite. Displacement sensors were connected at two locations on the outside of the outer shell. With the perlite not compacted, the inner tank was thermally cycled and the difference in the two displacements was measured as the inner tank warmed and pressed on the perlite.

The perlite was then compacted by hand in two areas while the inner tank was cold in order to mechanically couple the inner and outer shells. When the inner tank was allowed to warm and expand, it deformed the outer tank into an elliptical shape, and the displacement sensors detected different motions for the fluffy and compacted perlite. In any location where the perlite was still fluffy and not compacted, there was no defor-

mation. In areas where the perlite was packed more solidly, the sensors detected a slight deflection. By running these checks between cycles, it becomes a simple matter to identify areas of perlite compaction, and replace it before it can cause damage to the outer shell.

*This work was done by Robert Youngquist of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13214*

## Using Thin-Film Thermometers as Heaters in Thermal Control Applications

NASA's Jet Propulsion Laboratory, Pasadena, California

A cryogenic sensor maintains calibration at  $\approx 4.2$  K to better than 2 mK (<0.5 percent resistance repeatability) after being heated to  $\approx 40$  K with  $\approx 0.5$  W power. The sensor withstands 4 W power dissipation when immersed in liquid nitrogen with verified resistance reproducibility of, at worst, 1 percent. The

sensor maintains calibration to 0.1 percent after being heated with 1-W power at  $\approx 77$  K for a period of 48 hours.

When operated with a readout scheme that is capable of mitigating the self-heating calibration errors, this and similar sensors can be used for precision (mK stability) temperature control with-

out the need of separate heaters and associated wiring/cabling.

*This work was done by Hyung J. Cho, Konstantin Penanen, Kalyani G. Sukhatme, and Warren A. Holmes of Caltech, and Scott Courts of Lake Shore Cryotronics for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46882*

## Directional Spherical Cherenkov Detector

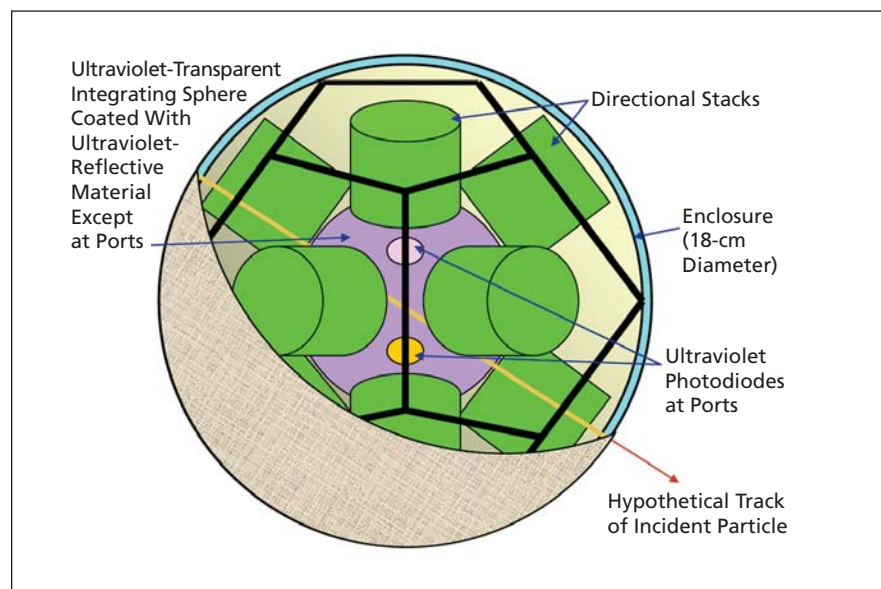
Incident particles could be sorted by direction, speed, and electric charge.

John H. Glenn Research Center, Cleveland, Ohio

A proposed radiation-detecting apparatus would provide information on the kinetic energies, directions, and electric charges of highly energetic incident subatomic particles. The apparatus was originally intended for use in measuring properties of cosmic rays in outer space, but could also be adapted to terrestrial uses — for example, radiation dosimetry aboard high-altitude aircraft and in proton radiation therapy for treatment of tumors.

The apparatus (see figure) would include a spherical Cherenkov detector surrounded by stacks of pairs of detectors. Each such pair and stack would be used in identifying incident particles and would respond to particles incident within a solid-angle range that, in conjunction with the number of such stacks, would define the angular resolution of the apparatus. The number of stacks and the number of pairs of detectors in each stack may be unlimited.

The detectors in each stack would typically have areas  $>1$  cm<sup>2</sup> and could be made, variously, from compensated sili-



A Spherical Cherenkov Detector would be combined with directional/triggering detector stacks.

con or from such wide-bandgap semiconductors as semi-insulating silicon carbide. Sheets of tungsten, lead, nickel, iron, and/or alloys thereof, serving as

energy-moderating materials, could be inserted between detectors to enable discrimination of particles by energy. A scintillation counter could be used as a

particle trigger with, or in place of, the detector stack.

The spherical Cherenkov detector would include a sphere of ultraviolet-transparent material (e.g., sapphire, quartz, or an acrylic polymer) having an ultraviolet index of refraction greater than 1. The sphere would be coated with an ultraviolet-reflecting material except at small ports. SiC photodiodes or optical fibers leading to photodiodes would be mounted facing into the sphere at the ports to enable detection of Cherenkov ultraviolet light emitted within the sphere.

The detectors in the stacks would serve as triggers for collection of light by the photodiodes of the spherical

Cherenkov counter. The direction and length of the path of a triggering particle would be determined from the identities (and thus the positions) of the affected detectors and stacks. For incident ions having sufficiently high kinetic energies, the strengths of the signals from the SiC photodiodes or optical fibers would be proportional to the square of the electric charges of the ions multiplied by the path lengths. Hence, a velocity distribution for high-energy ions incident from multiple directions could be determined.

For less-energetic incident particles, further sorting could be accomplished through correlation of the Cherenkov signal from the sphere with differences

among signals from stacked detectors that have different thicknesses and that may be interspersed with energy-moderating materials. Sensitivity of detection could be increased through substitution of low-noise SiC detectors for ordinary SiC detectors.

*This work was done by John D. Wrbanek, Gustave C. Fralick, and Susan Y. Wrbanek of 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: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18362-1.*

## AlGa<sub>x</sub>N Ultraviolet Detectors for Dual-Band UV Detection

**This technology can be used in multicolor imaging for flame temperature sensing and counter-camouflage/biosensing applications.**

*Goddard Space Flight Center, Greenbelt, Maryland*

This innovation comprises technology that has the ability to measure at least two ultraviolet (UV) bands using one detector without relying on any external optical filters. This allows users to build a miniature UVA and UVB monitor, as well as to develop compact, multicolor imaging technologies for flame temperature sensing, air-quality control, and terrestrial/counter-camouflage/biosensing applications.

The structure is designed for back illumination and contains six AlGa<sub>x</sub>N layers with different doping, Al percentage, and two contacts — A and B. The cut-off wavelength of AlGa<sub>x</sub>N can be tuned from 200 nm to 365 nm by changing the Al percentage. There are three band-edges in this structure that correspond to Al<sub>x</sub>Ga<sub>1-x</sub>N, Al<sub>y</sub>Ga<sub>1-y</sub>N, and Al<sub>z</sub>Ga<sub>1-z</sub>N —  $x$ ,  $y$ , and  $z$  should be designed to be  $x > y > z$  for back illumination.

When photons are injected from the backside, they will be absorbed at differ-

ent layers depending on the wavelength of the photons. Electrically, the device is a back-to-back pin structure along the vertical direction. When B is biased positively, and A is connected to the ground, the bottom pin is forwardly biased and acts as a current variable resistor with resistance becoming negligible when the bias on B is high enough. While the bottom pin is forward biased, the top pin junction is reverse biased and acts as a detector. Because the depletion mainly happens in the n-Al<sub>z</sub>Ga<sub>1-z</sub>N layer, only the photons absorbed in n-Al<sub>z</sub>Ga<sub>1-z</sub>N will be converted into photon-current. When the bias is applied in an opposite manner, in which B is biased negatively and A is connected to the ground, the bottom pin is biased in reverse and acts as an active detector. The depletion region is mainly in n-Al<sub>y</sub>Ga<sub>1-y</sub>N and the photons with  $wx < wp < wy$  can be converted into photocurrent. When  $wp < wx$ , all photons will

be absorbed in the bottom n-Al<sub>x</sub>Ga<sub>1-x</sub>N layer. Most of the photoelectrons will be recombined locally without generating photocurrent.

By changing the polarity of the bias, the detector can selectively detect two different wavebands:  $wy < wp < wz$ , when positive bias is applied on A, and  $wx < wp < wy$  when negative bias is applied on A. The detector is blind to  $wp < wx$  (no photocurrent) and  $wp > wz$  (no absorption). Practically,  $wx$ ,  $wy$ , and  $wz$  are tunable between 250 nm to 300 nm. The percentage of Al in the p+ layer in the center can be any number between  $y$  and  $z$ . As a result, the two detection bands do not have to be continuous.

*This work was done by Laddawan Miko, David Franz, and Carl M. Stahle of Goddard Space Flight Center and Feng Yan and Bing Guan of MEI Technologies, Inc. Further information is contained in a TSP (see page 1). GSC-15163-1*