trated in the left part of the figure. For another example, it was found that potentials between 2 and 3 kV applied for times <2 s while the electrode was held stationary yield hexagons (a consequence of the crystalline structure of $LiNbO_3$), as illustrated in the right part of Figure 2.

Among the advantages of calligraphic poling is that it is possible to visually observe the domains in ordinary (that is, non-polarized) light as they are being formed. Light incident from above along the *z*-axis travels through the wafer and is reflected from its bottom surface. The poling electric field magnifies the gradient in the index of refraction between a +*z*- and –*z*-poled region to such an extent as to give rise to a dark outline, coinciding with the boundary between the regions, that is visible in the reflected light when viewed from above through a conventional optical microscope. In addition, it is possible to view the domains nondestructively after they have been formed, because a potential sufficient to generate the dark outline (typically 200 V) is much smaller than the domain-reversal potential.

This work was done by Makan Mohageg, Dmitry Strekalov, Anatoliy Savchenkov, Adrey Matsko, Lute Maleki, and Vladimir Iltchenko 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-41566, volume and number of this NASA Tech Briefs *issue, and the page number.*

Blackbody Cavity for Calibrations at 200 to 273 K

Care must be taken to ensure high emissivity to minimize error.

Stennis Space Center, Mississippi

A laboratory blackbody cavity has been designed and built for calibrating infrared radiometers used to measure radiant temperatures in the range from about 200 to about 273 K. In this below-room-temperature range, scattering of background infrared radiation from room-temperature surfaces could, potentially, contribute significantly to the spectral radiance of the blackbody cavity, thereby contributing a significant error to the radiant temperature used as the calibration value. The spectral radiance error at wavelength λ is given by

$$[1 - \varepsilon(\lambda)][B(T_c,\lambda) + B(T_a,\lambda)],$$

where $\varepsilon(\lambda)$ is the effective spectral emissivity of the cavity, $B(T,\lambda)$ is the ideal spectral radiance of a body at absolute temperature T according to Planck's radiation law, T_c is the temperature in the cavity, and T_a is the ambient temperature. Examining the above expression shows that by making $\varepsilon(\lambda)$ as close as possible to unity, one can minimize the spectral-radiance error and the associated radiant-temperature error. For example, it has been calculated that to obtain a radiant-temperature error of 1 K or less at a cavity temperature of 200 K, ambient temperature of 300 K, and wavelength of 6 μm, one has $\varepsilon(\lambda)>0.999$ (see Figure 1). A 1 K radiant-temperature error is more than sufficient for atmospheric and cloud studies, which is a common application of infrared radiometers.

The present blackbody cavity is of an established type in which multiple reflections from a combination of conical and cylindrical black-coated walls (see Figure 2) are exploited to obtain an effective emissivity greater than the emissivity value of the coating material on a flat exposed surface. The coating material in this case is a flat black paint that has an emissivity of approximately 0.91 in the thermal spectral range and was selected over other, higher-emissivity materials because of its ability to withstand thermal cycling. We found many black coatings cracked and flaked after thermal cycling due to differences in the coefficient of expansion. On the basis of theoretical calculations, the effective emissivity is expected to approach 0.999.

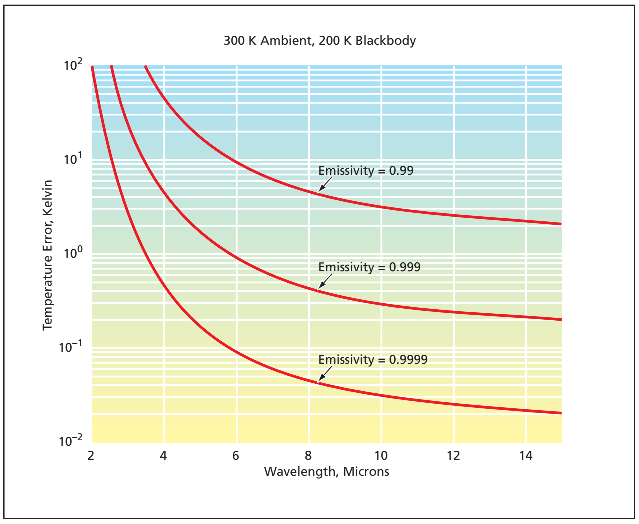

Figure 1. The **Error in the Radiant Temperature** as a function of wavelength was calculated for three different emissivity values for a cavity temperature of 200 K and ambient temperature of 300 K.

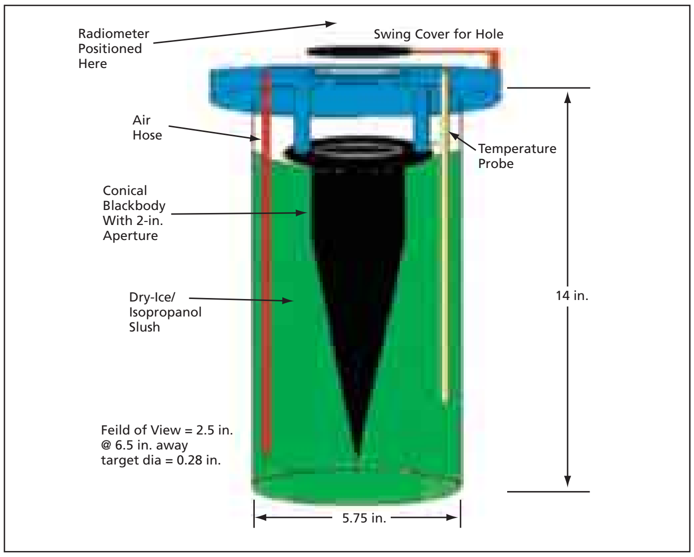

Figure 2. The **Blackbody Cavity** has a shape and size chosen as a compromise among maximizing the number of internal reflections, maximizing effective emissivity out to an acceptably large radius, and keeping the cone short enough to fit in a Dewar flask, as shown.

The cylindrical/conical shell enclosing the cavity is machined from copper, which is chosen for its high thermal conductivity. In use, the shell is oriented vertically, open end facing up, and inserted in a Dewar flask filled with isopropyl alcohol/dry-ice slush. A flange at the open end of the shell is supported by a thermally insulating ring on the lip of the Dewar flask. The slush cools the shell (and thus the blackbody cavity) to the desired temperature. Typically, the slush starts at a temperature of about 194 K. The slush is stirred and warmed by bubbling dry air or nitrogen through it, thereby gradually increasing the temperature through the aforementioned calibration range during an interval of several hours. The temperature of the slush is monitored by use of a precise thermocouple probe. A comparison with an independently calibrated commercial radiometer with a thermocouple demonstrated less than a 1 K difference between a thermocouple in the slush and the radiometer's output. The flow of dry air also acts as a purge to prevent airborne water vapor from frosting the conical and cylindrical cavity surfaces.

This work was done by Dane Howell, Robert Ryan, Jim Ryan, Dane Howell, Doug Henderson, and Larry Clayton of Stennis Space Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center, (228) 688-1929. Refer to SSC-00193.

KML Super Overlay to WMS Translator

NASA's Jet Propulsion Laboratory, Pasadena, California

This translator is a server-based application that automatically generates KML super overlay configuration files required by Google Earth for map data access via the Open Geospatial Consortium WMS (Web Map Service) standard. The translator uses a set of URL parameters that mirror the WMS parameters as much as possible, and it also can generate a super overlay subdivision of any given area that is only loaded when needed, enabling very large areas of coverage at very high resolutions. It can make almost any dataset available as a WMS service visible and usable in any KML application, without the need to reformat the data.

With the proper configuration, very large datasets that exist in WMS can become layers in a KML-enabled client. For example, Google Earth natively uses KML for data access and is both popular and available. This KML to WMS translator makes Google Earth act as a WMS client and can be used to make NASA remote sensing data more accessible, thus enabling exploration, collaboration, and education efforts. Simulated or modeled data available in WMS can become available in KML. This tool can be used for remote imagery of other planets, the Moon, and Earth.

This program was written by Lucian Plesea of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44684.

High-Performance Tiled WMS and KML Web Server

NASA's Jet Propulsion Laboratory, Pasadena, California

This software is an Apache 2.0 module implementing a high-performance map server to support interactive map viewers and virtual planet client software. It can be used in applications that require access to very-high-resolution geolocated images, such as GIS, virtual planet applications, and flight simulators. It serves Web Map Service (WMS) requests that comply with a given request grid from an existing tile dataset. It also generates the KML super-overlay configuration files required to access the WMS image tiles. This server can sustain extremely high request rates with very short request latencies in both WMS and KML protocols. It does not require significant computer resources and can operate from read-only media.

This server makes it possible to support very demanding interactive or immersive applications that require geographically located data. It has direct applications for making NASA data such as remote sensing and modeled or simulated data available to applications like WorldWind or Google Earth.

This program was written by Lucian Plesea of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO- 44685.

Modeling of Radiative Transfer in Protostellar Disks

NASA's Jet Propulsion Laboratory, Pasadena, California

This program implements a spectral line, radiative transfer tool for interpreting Spitzer Space Telescope observations by matching them with models of protostellar disks for improved understanding of planet and star formation. The Spitzer Space Telescope detects gas-phase molecules in the infrared spectra of protostellar disks, with spectral lines carrying information on the chemical composition of the material from which planets form. Input to the software in-