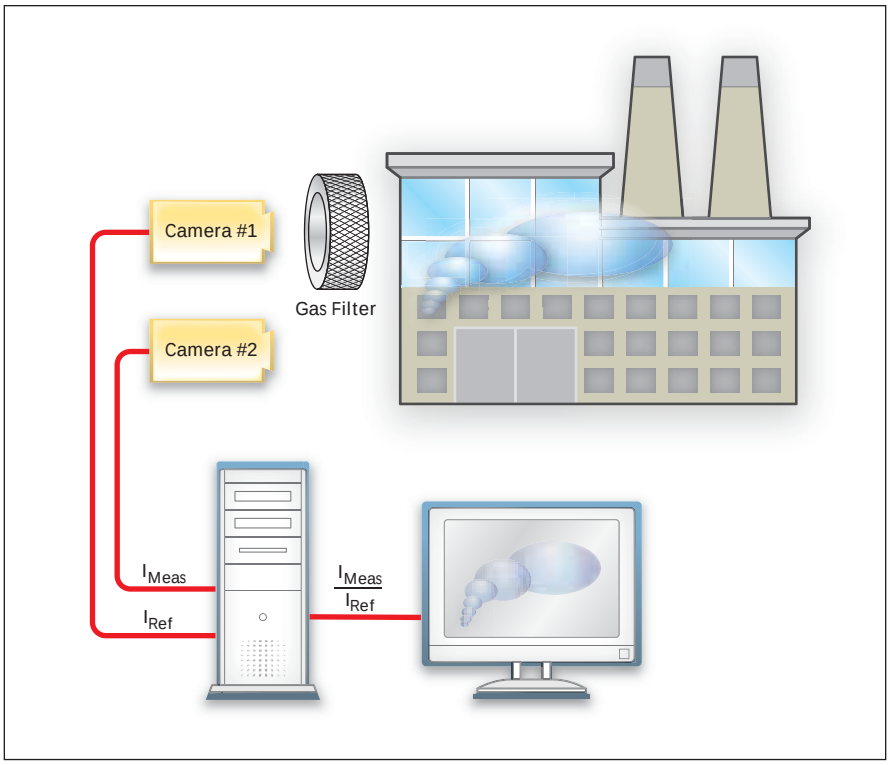


The **Two-Camera Version of the Infrared Camera System** features two cameras with essentially the same view and time.

same signal ratio is obtained for both high- and low-background signals, even though the low-signal areas may have greater noise content due to their smaller signal strength. Thus, one embodiment would use a ratioed output signal to better represent the gas column concentration.

An alternative approach uses a simpler multiplication of the filtered signal to make the filtered signal equal to the unfiltered signal at most locations, followed by a subtraction to remove all but the wavelength-specific absorption in the unfiltered sample. This signal processing can also reveal the net difference signal representing the leaking gas absorption, and allow rapid leak location, but signal intensity would not relate solely to gas absorption, as raw signal intensity would also affect the displayed signal.

A second design choice is whether to use one camera with two images closely spaced in time, or two cameras with essentially the same view and time. The figure shows the two-camera version. This choice involves many tradeoffs that are not apparent until some detailed testing is done. In short, the tradeoffs involve the temporal changes in the field picture versus the pixel sensitivity curves and frame alignment differences with two cameras, and which system would lead to the smaller variations from the uncontrolled variables.

*This work was done by Robert Youngquist and Dale Lueck of Kennedy Space Center and Christopher Immer and Robert Cox of ASRC Aerospace Corporation. Further information is contained in a TSP (see page 1).*
*KSC-13207*

# Submonolayer Quantum Dot Infrared Photodetector

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A method has been developed for inserting submonolayer (SML) quantum dots (QDs) or SML QD stacks, instead of conventional Stranski-Krastanov (S-K) QDs, into the active region of intersubband photodetectors. A typical configuration would be InAs SML QDs embedded in thin layers of GaAs, surrounded by AlGaAs barriers. Here, the GaAs and the AlGaAs have nearly the same lattice constant, while InAs has a larger lattice constant.

In QD infrared photodetector, the important quantization directions are in the plane perpendicular to the normal incidence radiation. In-plane quantization is what enables the absorption of normal incidence radiation. The height of the S-K QD controls the positions of the quantized energy levels, but is not critically important to the desired normal incidence absorption properties. The SML QD or SML QD stack configurations give more control of the structure grown, retains normal incidence absorption properties, and decreases the strain build-up to allow thicker active layers for higher quantum efficiency.

*This work was done by David Z. Ting, Sumith V. Bandara, and Sarath D. Gunapala of Caltech and Yia-Chung Chang of the University of Illinois for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*
*NPO-46115*

# Mode Tracker for Mode-Hop-Free Operation of a Laser

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

A mode-tracking system that includes a mode-controlling subsystem has been incorporated into an external-cavity (EC) quantum cascade laser that operates in a mid-infrared wavelength range. The mode-tracking system makes it possible to perform mode-hop-free wavelength scans, as needed for high-resolution spectroscopy and detection of trace gases. The laser includes a gain chip, a beam-collimating lens, and a diffraction grating. The grating is mounted on a platform, the position of which can be varied to effect independent control of the EC length and the grating angle.

The position actuators include a piezoelectric stage for translation control and a motorized stage for coarse rotation control equipped with a piezoelectric actuator for fine rotation control. Together, these actuators enable control of the EC length over a range of about 90 μm with a resolution of 0.9 nm, and control of the grating angle over a coarse-tuning range of ±6.3° and a fine-tuning range of ±520 μrad with a resolution of 10 nrad. A mirror mounted on the platform with the grating assures always the same direction of the output laser beam.

*This work was done by Gerard Wysocki, Frank K. Tittel, and Robert F. Curl of Rice University for Johnson Space Center.*

*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:*

*Rice University*
*Office of Technology Transfer*
*MS-705*
*6100 Main Street*
*Houston Texas 77005-1892*
*Phone No: (713)-348-6188*
*E-mail: techtran@rice.edu*

*Refer to MSC-24088-1, volume and number of this* NASA Tech Briefs *issue, and the page number.*

# Fiber-Optic Continuous Liquid Sensor for Cryogenic Propellant Gauging

## Either water or liquid nitrogen levels can be measured within 1-mm spatial resolution and 1°C up to a distance of 70 m from the optical interrogation unit.

*John H. Glenn Research Center, Cleveland, Ohio*

An innovative fiber-optic sensor has been developed for low-thrust-level settled mass gauging with measurement uncertainty <0.5 percent over cryogenic propellant tank fill levels from 2 to 98 percent. The proposed sensor uses a single optical fiber to measure liquid level and liquid distribution of cryogenic propellants. Every point of the sensing fiber is a "point sensor" that not only distinguishes liquid and vapor, but also measures temperature. This sensor is able to determine the physical location of each "point sensor" with 1-mm spatial resolution. Acting as a continuous array of numerous liquid/vapor point sensors, the truly distributed optical sensing fiber can be installed in a propellant tank in the same manner as silicon diode point sensor stripes using only a single feedthrough to connect to an optical signal interrogation unit outside the tank.

Either water or liquid nitrogen levels can be measured within 1-mm spatial resolution up to a distance of 70 meters from the optical interrogation unit. This liquid-level sensing technique was also compared to the pressure gauge measurement technique in water and liquid nitrogen contained in a vertical copper pipe with a reasonable degree of accuracy. It has been demonstrated that the sensor can measure liquid levels in multiple containers containing water or liquid nitrogen with one signal interrogation unit. The liquid levels measured by the multiple fiber sensors were consistent with those virtually measured by a ruler.

The sensing performance of various optical fibers has been measured, and has demonstrated that they can survive after immersion at cryogenic temperatures. The fiber strength in liquid nitrogen has also been measured. Multiple water level tests were also conducted under various actual and theoretical vibration conditions, and demonstrated that the signal-to-noise ratio under these vibration conditions, insofar as it affects measurement accuracy, is manageable and robust enough for a wide variety of spacecraft applications. A simple solution has been developed to absorb optical energy at the termination of the optical sensor, thereby avoiding any feedback to the optical interrogation unit.

*This work was done by Wei Xu of Broadband Photonics 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: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18505-1.*

# Ionization-Assisted Getter Pumping for Ultra-Stable Trapped Ion Frequency Standards

*NASA's Jet Propulsion Laboratory, Pasadena, California*

A method eliminates (or recovers from) residual methane buildup in getter-pumped atomic frequency standard systems by applying ionizing assistance. Ultra-high stability trapped ion frequency standards for applications requiring very high reliability, and/or low power and mass (both for ground-based and space-based platforms) benefit from using sealed vacuum systems. These systems require careful material selection and system processing (cleaning and high-temperature bake-out). Even under the most careful preparation, residual hydrogen outgassing from vacuum chamber walls typically limits the base pressure.

Non-evaporable getter pumps (NEGs) provide a convenient pumping option for sealed systems because of low mass and volume, and no power once activated. However, NEGs do not pump inert gases, methane, and some other hydrocarbon gases. For ultra-high vacuum applications, methane can become the single largest unpumped component. Methane collisions with trapped ions (such as $^{199}Hg^{+}$) used for frequency standard applications can produce de-coher-