quency passive isolation platform to filter spacecraft vibrations with voice coil actuators for active tip-tilt correction below the resonant frequency.

The canonical deep-space optical communications transceiver makes synergistic use of innovative technologies to reduce size, weight, power, and cost. This optical transceiver can be used to retire risks associated with deep-space optical communications on a planetary pathfinder mission and is complementary to ongoing lunar and access link developments.

This work was done by Gerard G. Ortiz, William H. Farr, and Jeffrey R. Charles of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). ***NPO-46073***

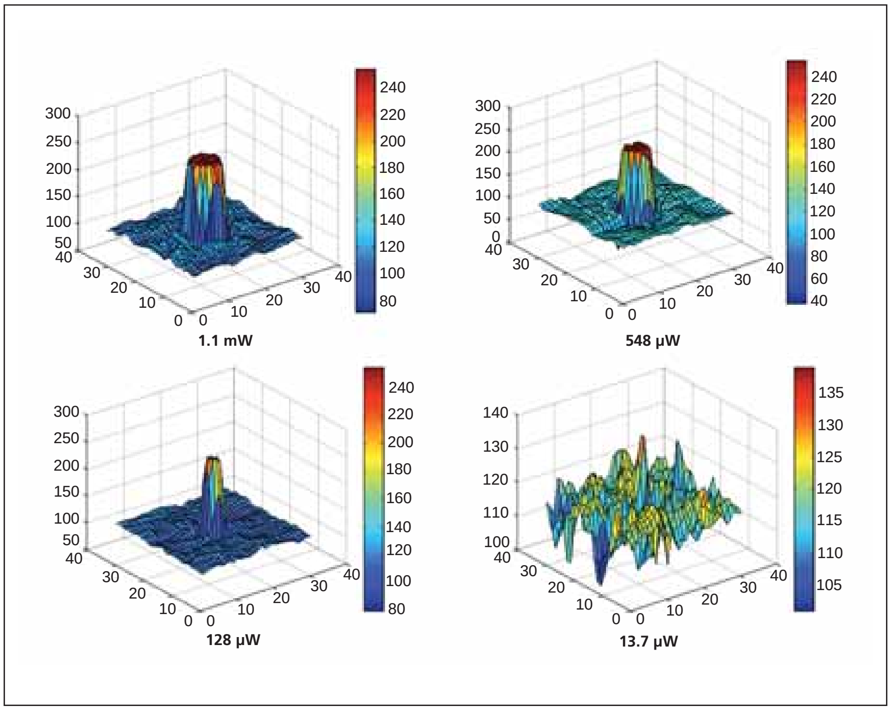
Two-Photon-Absorption Scheme for Optical Beam Tracking

This approach reduces cost for free-space optical communication receivers.

NASA's Jet Propulsion Laboratory, Pasadena, California

A new optical beam tracking approach for free-space optical communication links using two-photon absorption (TPA) in a high-bandgap detector material was demonstrated. This tracking scheme is part of the canonical architecture described in the preceding article. TPA is used to track a long-wavelength transmit laser while direct absorption on the same sensor simultaneously tracks a shorter-wavelength beacon. The TPA responsivity was measured for silicon using a PIN photodiode at a laser beacon wavelength of 1,550 nm. As expected, the responsivity shows a linear dependence with incident power level. The responsivity slope is 4.5 × 10^{-7} A/W^2. Also, optical beam spots from the 1,550-nm laser beacon were characterized on commercial charge-coupled device (CCD) and complementary metal-oxide semiconductor (CMOS) imagers with as little as 13.7 µW of optical power (see figure). This new tracker technology offers an innovative solution to reduce system complexity, improve transmit/receive isolation, improve optical efficiency, improve signal-to-noise ratio (SNR), and reduce cost for free-space optical communications transceivers.

This work was done by Gerardo G. Ortiz and William H. Farr of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). ***NPO-46063***



Two-Photon Absorption generated signal levels caused by a 1,550 nm laser focused spot on a silicon CMOS focal plane array detector at various power levels. Note that the spot is distinguishable even with incident power levels in the 10's of microwatts.

High-Sensitivity, Broad-Range Vacuum Gauge Using Nanotubes for Micromachined Cavities

NASA's Jet Propulsion Laboratory, Pasadena, California

A broad-range vacuum gauge has been created by suspending a single-walled carbon nanotube (SWNT) (metallic or semiconducting) in a Schottky diode format or in a bridge conductor format, between two electrically charged mesas. SWNTs are highly sensitive to molecular collisions because of their extremely small diameters in the range of 1 to 3 nanometers. The measurement parameter will be the change in conductivity of SWNT due to decreasing rate of molecular collisions as the pressure inside a chamber decreases.

The rate of heat removal approaches a saturation limit as the mean free path (m.f.p.) lengths of molecules increase due to decreasing pressure. Only those sensing elements that have a long relaxation time can produce a measureable response when m.f.p. of molecules increases (or time between two consecutive collisions increases). A suspended SWNT offers such a capability because of its one-dimensional nature and ultra-small diameter. In the initial approach, similar architecture was used as that of a SWNT-Schottky diode that has been developed at JPL, and has its changing conductivity measured as the test chamber is pumped down from atmospheric pressure to high vacuum (10^{-7} Torr). Continuous response of decreasing conductivity has been measured as a function of decreasing pressure (SWNT is a negative thermal coefficient material) from atmosphere to $<10^{-6}$ Torr. A measureable current change in the hundreds of nA range has been recorded in the 10^{-6} Torr regime.

This work was done by Harish Manohara and Anupama B. Kaul of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

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
E-mail: iaoffice@jpl.nasa.gov

Refer to NPO-45383, volume and number of this NASA Tech Briefs *issue, and the page number.*

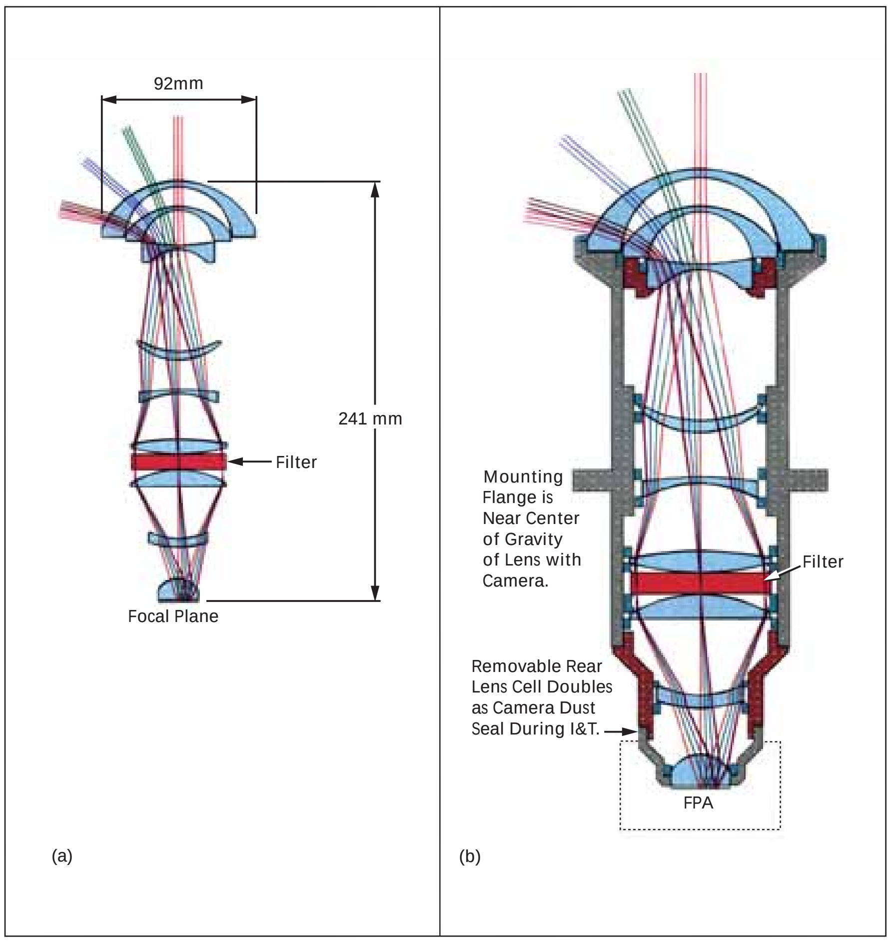
Wide-Field Optic for Autonomous Acquisition of Laser Link

This system has application in conventional wide-angle imaging such as low-light cockpit imaging, and in long-range motion detection.

NASA's Jet Propulsion Laboratory, Pasadena, California

An innovation reported in "Two-Camera Acquisition and Tracking of a Flying Target," *NASA Tech Briefs*, Vol. 32, No. 8 (August 2008), p. 20, used a commercial fish-eye lens and an electronic imaging camera for initially locating objects with subsequent handover to an actuated narrow-field camera. But this operated against a dark-sky background. An improved solution involves an optical design based on custom optical components for the wide-field optical system that directly addresses the key limitations in acquiring a laser signal from a moving source such as an aircraft or a spacecraft.

The first challenge was to increase the light collection entrance aperture diameter, which was approximately 1 mm in the first prototype. The new design presented here increases this entrance aperture diameter to 4.2 mm, which is equivalent to a more than 16 times larger collection area. One of the trades made in realizing this improvement was to restrict the field-of-view to +80° elevation and 360° azimuth. This trade stems from practical considerations where laser beam propagation over the excessively high air mass, which is in the line of sight (LOS) at low elevation angles, results in vulnerability to severe atmospheric turbulence and attenuation. An additional benefit of the new design is that the large entrance aperture is maintained even at large off-axis angles when the optic is pointed at zenith.



(a) The custom optical design and ray-trace of the **Wide-Field Optical Assembly**; and (b) a **Conceptual Optomechanical Design** for holding the optical components and providing interface to the focal plane array (FPA). The collected light is substantially collimated prior to being passed through the spectral filter.

The second critical limitation for implementing spectral filtering in the design was tackled by collimating the light prior to focusing it onto the focal plane. This allows the placement of the narrow spectral filter in the collimated portion of the beam. For the narrow band spectral filter to function properly, it is necessary to adequately control the range of incident angles at which received light intercepts the filter. When this angle is restricted via collimation, narrower spectral filtering can be implemented. The collimated beam (and the filter) must be relatively large to reduce the incident angle down to only a few degrees. In the presented embodiment, the filter diameter is more than ten times larger than the entrance aperture.