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:

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

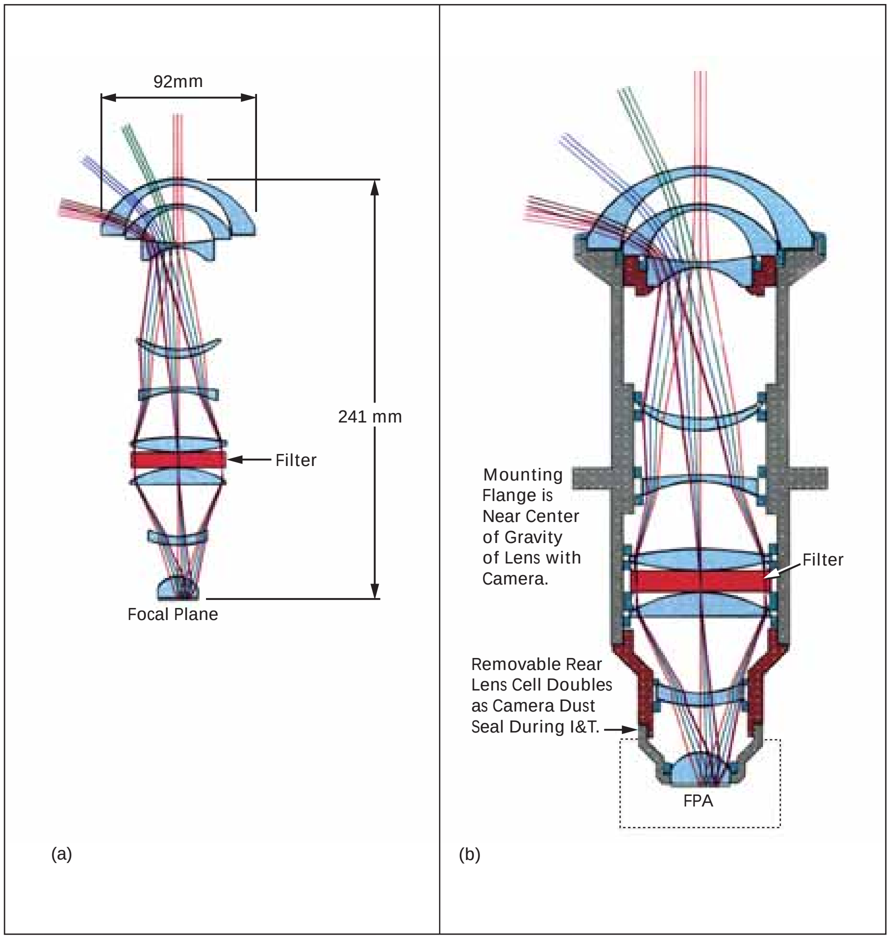
Wide-Field Optic for Autonomous Acquisition of Laser Link

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.

Specifically, the filter has a clear aperture of about 51 mm.

The optical design is refractive, and is comprised of nine custom refractive elements and an interference filter. The restricted maximum angle through the narrow-band filter ensures the efficient use of a 2-nm noise equivalent bandwidth spectral width optical filter at low elevation angles (where the range is longest), at the expense of less efficiency for high elevations, which can be tolerated because the range at high elevation angles is shorter. The image circle is 12 mm in diameter, mapped to 80×360° of sky, centered on the zenith.

This work was done by Norman A. Page, Jeffrey R. Charles, and Abhijit Biswas of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46945

Extracting Zero-Gravity Surface Figure of a Mirror

NASA's Jet Propulsion Laboratory, Pasadena, California

The technical innovation involves refinement of the classic optical technique of averaging surface measurements made in different orientations with respect to gravity, so the effects of gravity cancel in the averaged image. Particularly for large, thin mirrors subject to substantial deformation, the further requirement is that mount forces must also cancel when averaged over measurement orientations. The zero-gravity surface figure of a mirror in a hexapod mount is obtained by analyzing the summation of mount forces in the frame of the optic as surface metrology is averaged over multiple clockings. This is illustrated with measurements taken from the Space Interferometry Mission (SIM) PT-Ml mirror for both twofold and threefold clocking. The positive results of these measurements and analyses indicate that, from this perspective, a lighter mirror could be used; that is, one might place less reliance on the damping effects of the elliptic partial differential equations that describe the propagation of forces through glass.

The advantage over prior art is relaxing the need for an otherwise substantial thickness of glass that might be needed to ensure accurate metrology in the absence of a detailed understanding and analysis of the mount forces. The general insights developed here are new, and provide the basic design principles on which mirror mount geometry may be chosen.

This work was done by Eric E. Bloemhof, Jonathan C. Lam, V. Alfonso Feria, and Zensheu Chang of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47259