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 $4.5 \times 10^{-7}$ 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.

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 pressure. Only those sensing elements that have a long relaxation time can produce a measurable response when m.f.p. of molecules increases (or time between two consecutive collisions increases). A suspended SWNT offers such a capability because (m.f.p.) lengths of molecules increase due to decreasing pressure.
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 de-
developed at JPL, and has its changing
conductivity measured as the test cham-
ber is pumped down from atmospheric
pressure to high vacuum (10^{-7} Torr).
Continuous response of decreasing con-
ductivity has been measured as a func-
tion of decreasing pressure (SWNT is a
negative thermal coefficient material) from atmosphere to <10^{-6} Torr. A mea-
sureable current change in the hun-
dreds of nA range has been recorded in
the 10^{-6} Torr regime.

This work was done by Harish Manohara
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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 com-
mercial 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 back-
ground. 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 sig-
nal from a moving source such as an air-
craft or a spacecraft.

The first challenge was to increase the
light collection entrance aperture diam-
eter, which was approximately 1 mm in
the first prototype. The new design pre-
posed here increases this entrance aper-
ture 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 re-
strict 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, re-
results in vulnerability to severe atmos-
pheric turbulence and attenuation. An
additional benefit of the new design is
that the large entrance aperture is main-
tained even at large off-axis angles when
the optic is pointed at zenith.

The second critical limitation for im-
plementing 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 ade-
equately control the range of incident an-
gles at which received light intercepts the
filter. When this angle is restricted via col-
limation, 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 embodi-
ment, the filter diameter is more than ten
times larger than the entrance aperture.