



Books & Reports

Corner-Cube Retroreflector Instrument for Advanced Lunar Laser Ranging

A paper describes how, based on a structural-thermal-optical-performance analysis, it has been determined that a single, large, hollow corner cube (170-mm outer diameter) with custom dihedral angles offers a return signal comparable to the Apollo 11 and 14 solid-corner-cube arrays (each consisting of 100 small, solid corner cubes), with negligible pulse spread and much lower mass. The design of the corner cube, and its surrounding mounting and casing, is driven by the thermal environment on the lunar surface, which is subject to significant temperature variations (in the range between 70 and 390 K). Therefore, the corner cube is enclosed in an insulated container open at one end; a narrow-band-pass solar filter is used to reduce the solar energy that enters the open end during the lunar day, achieving a nearly uniform temperature inside the container. Also, the materials and adhesive techniques that will be used for this corner-cube reflector must have appropriate thermal and mechanical characteristics (e.g., silica or beryllium for the cube and aluminum for the casing) to further reduce the impact of the thermal environment on the instrument's performance.

The instrument would consist of a single, open corner cube protected by a separate solar filter, and mounted in a cylindrical or spherical case. A major goal in the design of a new lunar ranging system is a measurement accuracy improvement to better than 1 mm by reducing the pulse spread due to orientation. While achieving this goal, it was desired to keep the intensity of the return beam at least as bright as the Apollo 100-corner-cube arrays. These goals are met in this design by increasing the optical aperture of a single corner cube to approximately 170 mm outer diameter. This use of an "open" corner cube allows the selection of corner cube materials to be based primarily on thermal considerations, with no requirements on optical transparency. Such a corner cube also allows for easier pointing requirements, because there is no dependence on total internal reflection, which can fail off-axis.

This work was done by Slava G. Turyshev, William M. Folkner, Gary M. Gutt, James G. Williams, Ruwan P. Somawardhana, and Richard T. Baran of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47489

Electrospray Collection of Lunar Dust

A report describes ElectroSpray Ionization based Electrostatic Precipitation (ESIEP) for collecting lunar dust particles. While some HEPA filtration processes may remove a higher fraction (>99.9 percent) of the particles, the high efficiency may not be appropriate from an overall system standpoint, especially in light of the relatively large power requirement that such systems demand.

The new electrospray particle capture technology (inspired by the late Nobel Laureate Dr. John B. Fenn) is described as a variant of electrostatic precipitation that eliminates the current drawbacks of electrostatic precipitation. The new approach replaces corona prone field with a mist of highly charged micro-droplets generated by electrospray ionization (ESI) as the mechanism by which incoming particles are attracted and captured. In electrospray, a minuscule flow rate (microliters/minute) of liquid (typically water and a small amount of salt to enhance conductivity) is fed from the tip of a needle held at a high voltage potential relative to an opposite counter electrode. At sufficient field strength, a sharp liquid meniscus forms (known as a so-called "Taylor Cone"), which emits a jet of highly charged droplets that drift through the surrounding gas and are collected on the walls of a conductive tube. Particles in the gas have a high probability of contact with the droplets either by adhering to the droplets or otherwise acquiring a high level of charge, causing them to be captured on the collecting electrode as well. The spray acts as a filtration material that is continuously introduced and removed from the gas flow, and thus can never become clogged.

Experiments determined that ESIEP can collect particles with efficiencies as high as or higher than traditional corona-based EP, owing to the higher specificity of charging and higher levels

of charge deposited on particles by the droplets. Removal rates of 95–99 percent and greater are typically observed, even at moderate gas flow rates — all without the generation of ozone due to corona discharge.

This work was done by Joseph Bango and Michael Dziekan of Connecticut Analytical Corp. 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: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18629-1.

Fabrication of a Kilopixel Array of Superconducting Microcalorimeters With Microstripline Wiring

A document describes the fabrication of a two-dimensional microcalorimeter array that uses microstrip wiring and integrated heat sinking to enable use of high-performance pixel designs at kilopixel scales (32×32). Each pixel is the high-resolution design employed in small-array test devices, which consist of a Mo/Au TES (transition edge sensor) on a silicon nitride membrane and an electroplated Bi/Au absorber. The pixel pitch within the array is 300 microns, where absorbers 290 microns on a side are cantilevered over a silicon support grid with 100-micron-wide beams. The high-density wiring and heat sinking are both carried by the silicon beams to the edge of the array. All pixels are wired out to the array edge.

ECR (electron cyclotron resonance) oxide underlayer is deposited underneath the sensor layer. The sensor (TES) layer consists of a superconducting underlayer and a normal metal top layer. If the sensor is deposited at high temperature, the ECR oxide can be vacuum annealed to improve film smoothness and etch characteristics.

This process is designed to recover high-resolution, single-pixel x-ray microcalorimeter performance within arrays of arbitrarily large format. The critical current limiting parts of the circuit are designed to have simple interfaces that can be independently verified. The lead-to-TES interface is entirely de-

terminated in a single layer that has multiple points of interface to maximize critical current. The lead rails that overlap the TES sensor element contact both the superconducting underlayer and the TES normal metal.

This work was done by James Chervenak of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15915-1

Spacecraft Attitude Tracking and Maneuver Using Combined Magnetic Actuators

A paper describes attitude-control algorithms using the combination of magnetic actuators with reaction wheel assemblies (RWAs) or other types of actuators such as thrusters. The combination of magnetic actuators with one or two RWAs aligned with different body axis expands the two-dimensional control torque to three-dimensional. The algorithms can guarantee the spacecraft attitude and rates to track the commanded attitude precisely.

A design example is presented for nadir-pointing, pitch, and yaw maneuvers. The results show that precise attitude tracking can be reached and the attitude-control accuracy is comparable with RWA-based attitude control. When there are only one or two workable

RWAs due to RWA failures, the attitude-control system can switch to the control algorithms for the combined magnetic actuators with the RWAs without going to the safe mode, and the control accuracy can be maintained.

The attitude-control algorithms of the combined actuators are derived, which can guarantee the spacecraft attitude and rates to track the commanded values precisely. Results show that precise attitude tracking can be reached, and the attitude-control accuracy is comparable with 3-axis wheel control.

This work was done by Zhiqiang Zhou of Langley Research Center. Further information is contained in a TSP (see page 1). LAR-17862-1

Coherent Detector for Near-Angle Scattering and Polarization Characterization of Telescope Mirror Coatings

A report discusses the difficulty of measuring scattering properties of coated mirrors extremely close to the specular reflection peak. A prototype Optical Heterodyne Near-angle Scatterometer (OHNS) was developed. Light from a long-coherence-length (>150 m) 532-nm laser is split into two arms. Acousto-optic modulators frequency shift the sample and reference

beams, establishing a fixed beat frequency between the beams. The sample beam is directed at very high f/# onto a mirror sample, and the point spread function (PSF) formed after the mirror sample is scanned with a pinhole. This light is recombined by a non-polarizing beam splitter and measured through heterodyne detection with a spectrum analyzer. Polarizers control the illuminated and analyzed polarization states, allowing the polarization dependent scatter to be measured.

The bidirectional reflective or scattering distribution function is normally measured through use of a scattering goniometer instrument. The instrumental beam width (collection angle span) over which the scatterometer responds is typically many degrees. The OHNS enables measurement at angles as small as the first Airy disk diameter.

This work was done by Steven A. Macenka of Caltech and Russell A. Chipman, Brian J. Daugherty, and Stephen C. McClain of the University of Arizona for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office-JPL. Refer to NPO-47310.