



### **Laser Truss Sensor for Segmented Telescope Phasing**

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

A paper describes the laser truss sensor (LTS) for detecting piston motion between two adjacent telescope segment edges. LTS is formed by two point-to-point laser metrology gauges in a crossed geometry.

A high-resolution (<30 nm) LTS can be implemented with existing laser metrology gauges. The distance change between the reference plane and the target plane is measured as a function of the phase change between the reference and target beams. To ease the bandwidth require-

ments for phase detection electronics (or phase meter), homodyne or heterodyne detection techniques have been used.

The phase of the target beam also changes with the refractive index of air, which changes with the air pressure, temperature, and humidity. This error can be minimized by enclosing the metrology beams in baffles. For longer-term (weeks) tracking at the micron level accuracy, the same gauge can be operated in the absolute metrology mode with an accuracy of microns; to implement ab-

solute metrology, two laser frequencies will be used on the same gauge. Absolute metrology using heterodyne laser gauges is a demonstrated technology. Complexity of laser source fiber distribution can be optimized using the range-gated metrology (RGM) approach.

*This work was done by Duncan T. Liu, Oliver P. Lay, Alireza Azizi, Herman Erlig, Leonard I. Dorsky, Cheryl G. Asbury, and Feng Zhao of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-47753*

### **Qualifications of Bonding Process of Temperature Sensors to Deep-Space Missions**

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

A process has been examined for bonding a platinum resistance thermometer (PRT) onto potential aerospace materials such as flat aluminum surfaces and a flexible copper tube to simulate coaxial cables for flight applications. Primarily, PRTs were inserted into a silver-plated copper braid to avoid stresses on the sensor while the sensor was attached with the braid to the base material for long-duration, deep-space missions.

Al-1145/graphite composite (planar substrate) and copper tube have been used in this study to assess the reliability of PRT bonding materials. A flexible copper tube was chosen to simulate the coaxial cable to attach PRTs. The sub-

strate materials were cleaned with acetone wipes to remove oils and contaminants. Later, the surface was also cleaned with ethyl alcohol and was air-dried. The materials were gently abraded and then were cleaned again the same way as previously mentioned.

Initially, shielded (silver plated copper braid) PRT (type X) test articles were fabricated and cleaned. The base antenna material was pretreated and shielded, and CV-2566 NuSil silicone was used to attach the shielded PRT to the base material. The test articles were cured at room temperature and humidity for seven days. The resistance of the PRTs was continuously monitored dur-

ing the thermal cycling, and the test articles were inspected prior to, at various intermediate steps during, and at the end of the thermal cycling as well. All of the PRTs survived three times the expected mission life for the JUNO project. No adhesion problems were observed in the PRT sensor area, or under the shielded PRT. Furthermore, the PRT resistance accurately tracked the thermal cycling of the chamber.

*This work was done by Rajeshuni Ramesham, Amarit Kitiyakara, Richard W. Redick III, and Eric T. Sunada of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-47682*

### **Optical Sensors for Monitoring Gamma and Neutron Radiation**

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

For safety and efficiency, nuclear reactors must be carefully monitored to provide feedback that enables the fission rate to be held at a constant target level via adjustments in the position of neutron-absorbing rods and moderating coolant flow rates. For automated reactor control, the monitoring system

should provide calibrated analog or digital output. The sensors must survive and produce reliable output with minimal drift for at least one to two years, for replacement only during refueling. Small sensor size is preferred to enable more sensors to be placed in the core for more detailed characterization of

the local fission rate and fuel consumption, since local deviations from the norm tend to amplify themselves. Currently, reactors are monitored by local power range meters (LPRMs) based on the neutron flux or gamma thermometers based on the gamma flux. LPRMs tend to be bulky, while gamma ther-

mometers are subject to unwanted drift. Both electronic reactor sensors are plagued by electrical noise induced by ionizing radiation near the reactor core.

A fiber optic sensor system was developed that is capable of tracking thermal neutron fluence and gamma flux in order to monitor nuclear reactor fission rates. The system provides near-real-time feedback from small-profile probes that are not sensitive to electromagnetic noise.

The key novel feature is the practical design of fiber optic radiation sensors. The use of an actinoid element to monitor neutron flux in fiber optic EFPI (extrinsic Fabry-Perot interferometric) sensors is a new use of material. The materials and structure used in the sensor construction can be adjusted to result in a sensor that is sensitive to just thermal, gamma, or neutron stimulus, or any combination of the three. The tested design showed low sensitivity to

thermal and gamma stimuli and high sensitivity to neutrons, with a fast response time.

*This work was done by Clark D. Boyd of Luna Innovations, Inc. for Glenn Research Center.*

*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-18701-1.*

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## Compliant Tactile Sensors

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

Tactile sensors are currently being designed to sense interactions with human hands or pen-like interfaces. They are generally embedded in screens, keyboards, mousepads, and pushbuttons. However, they are not well fitted to sense interactions with all kinds of objects.

A novel sensor was originally designed to investigate robotics manipulation where not only the contact with an object needs to be detected, but also where the object needs to be held and manipulated. This tactile sensor has been designed with features that allow it to sense a large variety of objects in human environments.

The sensor is capable of detecting forces coming from any direction. As a result, this sensor delivers a force vector with three components. In contrast to most of the tactile sensors that are flat, this one sticks out from the surface so that it is likely to come in contact with

objects. The sensor conforms to the object with which it interacts. This augments the contact's surface, consequently reducing the stress applied to the object. This feature makes the sensor ideal for grabbing objects and other applications that require compliance with objects. The operational range of the sensor allows it to operate well with objects found in peoples' daily life. The fabrication of this sensor is simple and inexpensive because of its compact mechanical configuration and reduced electronics. These features are convenient for mass production of individual sensors as well as dense arrays.

The biologically inspired tactile sensor is sensitive to both normal and lateral forces, providing better feedback to the host robot about the object to be grabbed. It has a high sensitivity, enabling its use in manipulation fingers, which typically have low mechanical impedance in

order to be very compliant. The construction of the sensor is simple, using inexpensive technologies like silicon rubber molding and standard stock electronics.

*This work was done by Eduardo R. Torres-Jara of the Massachusetts Institute of Technology for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.*

*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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## Cytometer on a Chip

**Analyses could be performed rapidly in compact instruments using disposable chips.**

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

A cytometer now under development exploits spatial sorting of sampled cells on a microarray chip followed by use of grating-coupled surface-plasmon-resonance imaging (GCSPRI) to detect the sorted cells. This cytometer on a chip is a prototype of contemplated future miniature cytometers that would be suitable for rapidly identifying pathogens and other cells of interest in both field and laboratory applications and that would be attractive as alternatives to conventional flow cytometers.

The basic principle of operation of a conventional flow cytometer requires fluorescent labeling of sampled cells, stringent optical alignment of a laser beam with a narrow orifice, and flow of the cells through the orifice, which is subject to clogging. In contrast, the principle of operation of the present cytometer on a chip does not require fluorescent labeling of cells, stringent optical alignment, or flow through a narrow orifice. The basic principle of operation of

the cytometer on a chip also reduces the complexity, mass, and power of the associated laser and detection systems, relative to those needed in conventional flow cytometry.

Instead of making cells flow in single file through a narrow flow orifice for sequential interrogation as in conventional flow cytometry, a liquid containing suspended sampled cells is made to flow over the front surface of a microarray chip on which there are many cap-