life and need extremely clean propellant feed systems at a significant cost, these $LaB_6$ cathodes can run on the crudest-grade xenon propellant available without impact. Moreover, in a laboratory environment, $LaB_6$ cathodes reduce testing costs because they do not require extended conditioning periods under hard vacuum. Alternative rare earth emitters, such as cerium hexaboride ($CeB_6$) can be used in this configuration with possibly an even longer emitter life.

This cathode is specifically designed to integrate on the centerline of a high-power Hall thruster, thus eliminating the asymmetries in the plasma discharge common to cathodes previously mounted externally to the thruster's magnetic circuit. An alternative configuration for the cathode uses an external propellant feed. This diverts a fraction of the total cathode flow to an external feed, which can improve the cathode coupling efficiency at lower total mass flow rates. This can improve the overall thruster efficiency, thereby decreasing the required propellant loads for different missions. Depending on the particular mission, reductions in propellant loads can lead to mission enabling capabilities by allowing launch vehicle step-down, greater payload capability, or by extending the life of a spacecraft.

*This work was done by Ronald Watkins of Columbus Technologies and Dan Goebel and Richard Hofer of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*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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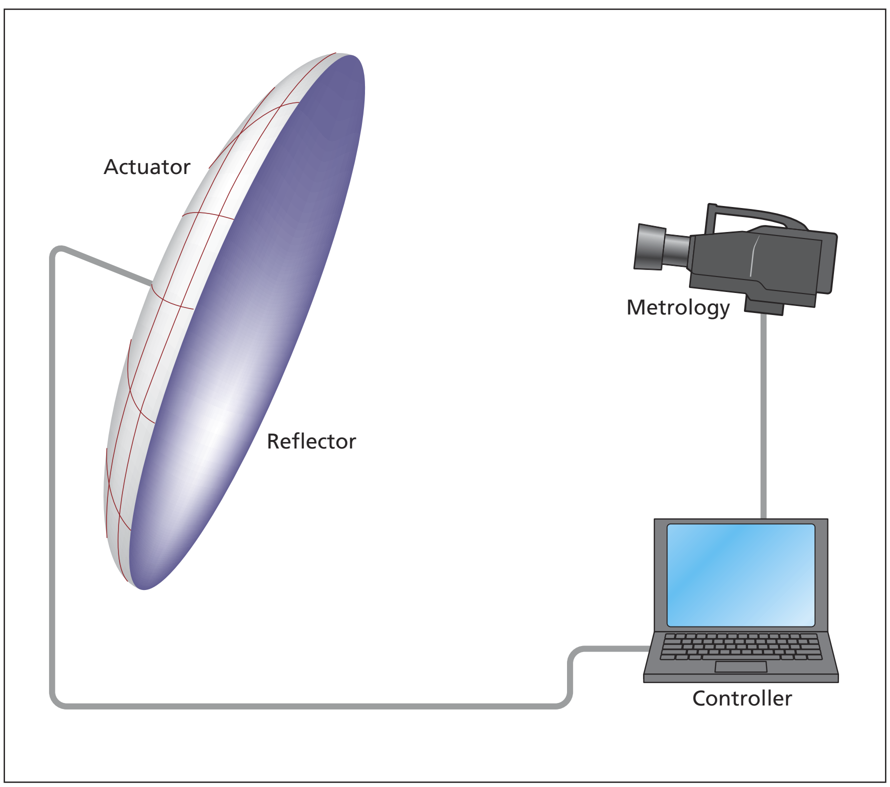
*Refer to NPO-44923, volume and number of this* NASA Tech Briefs *issue, and the page number.*

# High-Precision Shape Control of In-Space Deployable Large Membrane/Thin-Shell Reflectors

## Real-time reflector surface figure control uses piezoelectric polymer actuators.

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

This innovation has been developed to improve the resolutions of future space-based active and passive microwave antennas for earth-science remote sensing missions by maintaining surface figure precisions of large membrane/thin-shell reflectors during orbiting. The intention is for these sensing instruments to be deployable at orbit altitudes one or two orders of magnitude higher than Low Earth Orbit (LEO), but still being able to acquire measurements at spatial resolution and sensitivity similar to those of LEO. Because active and passive microwave remote sensors are able to penetrate through clouds to acquire vertical profile measurements of geophysical parameters, it is desirable to elevate them to the higher orbits to obtain orbital geometries that offer large spatial coverage and more frequent observations. This capability is essential for monitoring and for detailed understanding of the life cycles of natural hazards, such as hurricanes, tropical storms, flash floods, and tsunamis.




The **Major Components** of the antenna surface control system are illustrated.

Major components of this high-precision antenna-surface-control system include a membrane/thin shell reflector, a metrology sensor, a controller, actuators, and corresponding power amplifier and signal conditioning electronics (see figure). Actuators are attached to the back of the reflector to produce contraction/expansion forces to adjust the shape of the thin-material reflector. The wavefront-sensing metrology system continuously measures the surface figure of the reflector, converts the surface figure to digital data and feeds the data to the controller. The controller determines the control parameters and generates commands to the actuator system. The flexible, piezoelectric polymer actuators are thus activated, providing the control forces needed to correct any distortions that exist in the reflector surface. Piezoelectric polymer actuators are very thin and flexible. They can be implemented on the back of the membrane/thin-shell reflector without introducing significant amounts of mass or stiffness to the reflector. They can be rolled up or folded to accommodate the packaging needed for launch.

An analytical model of the system, which includes the membrane reflector, actuator, and controller has been developed to investigate the functionality of this control system on a 35-meter-diameter membrane reflector. The performance of this system under external disturbances such as in space thermal loads and W-error due to inflation has been investigated. A subscale breadboard has been developed, and the functionality of this control concept has been demonstrated by this breadboard.

*This work was done by Houfei Fang and Eastwood Im of Caltech, and Kon-Well Wang and Qiming Zhang of Penn State University for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-44913*

# Rapid Active Sampling Package

**A field-deployable, battery-operated tool enables rock sampling in the field.**

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

A field-deployable, battery-powered Rapid Active Sampling Package (RASP), originally designed for sampling strong materials during lunar and planetary missions, shows strong utility for terrestrial geological use. The technology is proving to be simple and effective for sampling and processing materials of strength. Although this originally was intended for planetary and lunar applications, the RASP is very useful as a powered hand tool for geologists and the mining industry to quickly sample and process rocks in the field on Earth.

The RASP allows geologists to surgically acquire samples of rock for later laboratory analysis. This tool, roughly the size of a wrench, allows the user to cut away swaths of weathering rinds, revealing pristine rock surfaces for observation and subsequent sampling with the same tool. RASPing deeper (≈3–5 cm) exposes single rock strata *in-situ*. Where a geologist's hammer can only expose unweathered layers of rock, the RASP can do the same, and then has the added ability to capture and process samples into powder with particle sizes less than 150 microns, making it easier for XRD/XRF (x-ray diffraction/x-ray fluorescence). The tool uses a rotating rasp bit (or two counter-rotating bits) that resides inside or above the catch container. The container has an open slot to allow the bit to extend outside the container and to allow cuttings to enter and be caught. When the slot and rasp bit are in contact with a substrate, the bit is plunged into it in a matter of seconds to reach pristine rock.

A user in the field may sample a rock multiple times at multiple depths in minutes, instead of having to cut out huge, heavy rock samples for transport back to a lab for analysis. Because of the speed and accuracy of the RASP, hundreds of samples can be taken in one day. RASP-acquired samples are small and easily carried. A user can characterize more area in less time than by using conventional methods. The field-deployable RASP used a Ni/Cad rechargeable battery. Power usage was less than 1 W-h/cm$^3$ even when sampling strong basalts, so many samples could be taken on a single battery charge.

The prototype field RASP was equipped with a load tube in which sealable sample containers were inserted. Positioning the tool upside-down conveniently loaded the sample containers with powdered rock samples. This technology could be adapted to existing battery-operated rotary tools, or could be used as a stand-alone sampling tool.

*This work was done by Gregory Peters of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-44946*

# Miniature Lightweight Ion Pump

**This lightweight pump with no moving parts eliminates the need for a backup pump.**

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

This design offers a larger surface area for pumping of active gases and reduces the mass of the pump by eliminating the additional vacuum enclosure. There are three main components to this ion pump: the cathode and anode pumping elements assembly, the vacuum enclosure (made completely of titanium and used as the cathode and maintained at ground potential) containing the assembly, and the external magnet. These components are generally put in a noble diode (or differential) configuration of the ion pump technology. In the present state of the art, there are two cathodes, one made of titanium and the other of tantalum. The anodes are made up of an array of stainless steel cylinders positioned between the two cathodes.

All the elements of the pump are in a vacuum enclosure. After the reduction of pressure in this enclosure to a few microns, a voltage is applied between the cathode and the anode elements. Electrons generated by the ionization are accelerated toward the anodes that are confined in the anode space by the axial magnetic field. For the generation of the axial field along the anode elements, the magnet is designed in a C-configuration and is fabricated from rare earth magnetic materials (Nd-B-Fe or Sm-Co) possessing high energy product values, and the yoke is fabricated from the high permeability material (Hiperco-50A composed of Fe-Co-V). The electrons in this region collide with the gas molecules and generate their positive ions. These ions are accelerated into the cathode and eject cathode material (Ti). The neutral atoms deposit on the anode surfaces. Because of the chemical activity of