has been found to be at least twice the size of a standard width measurement; in some cases, considerably greater, indicating that at least half of the disturbed surface area would be neglected without this insight. The ZOI is used to calculate a more robust data set of volume measurements that can be used to computationally reconstruct a resultant profile for detailed analysis. Documenting additional changes to various surface roughness parameters also allows key material attributes of importance to ultimate design applications to be quantified, such as depth of penetration and final abraded surface roughness. Furthermore, by investigating the use of custom scratch tips for specific needs, the usefulness of having an abrasion metric that can measure the displaced volume in this standardized manner, and not just by scratch width alone, is reinforced. This benefit is made apparent when a tip creates an intricate contour having multiple peaks and valleys within a single scratch.

The current innovation consists of a software-driven method of quantitatively evaluating a scratch profile. The profile consists of measuring the topographical features of a scratch along the length of the scratch instead of the width at one location. The digitized profile data is then fed into software code, which evaluates enough metrics of the scratch to reproduce the scratch from the evaluated metrics.

There are three key differences between the current art and this innovation. First, scratch width does not quantify how far from the center of the scratch damage occurs (ZOI). Second, scratch width does not discern between material displacement and material removal from the scratch. Finally, several scratches may have the same width but different zones of interactions, different displacements, and different material removals. The current innovation allows quantitative assessment of all three.

This work was done by Kenneth W. Street, Jr. of Glenn Research Center, Ryan L. Kobrick of MIT, and David M. Klaus of the University of Colorado at Boulder. 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-18780-1.

Rover Low Gain Antenna Qualification for Deep Space Thermal Environments

NASA's Jet Propulsion Laboratory, Pasadena, California

A method to qualify the Rover Low Gain Antenna (RLGA) for use during the Mars Science Laboratory (MSL) mission has been devised. The RLGA antenna must survive all ground operations, plus the nominal 670 Martian sol mission that includes the summer and winter seasons of the Mars thermal environment. This qualification effort was performed to verify that the RLGA design, its bonding, and packaging processes are adequate.

The qualification test was designed to demonstrate a survival life of three times more than all expected ground testing, plus a nominal 670 Martian sol missions. Baseline RF tests and a visual inspection were performed on the RLGA hardware before the start of the qualification test. Functional intermittent RF tests were performed during thermal chamber breaks over the course of the complete qualification test. For the return loss measurements, the RLGA antenna was moved to a test area. A vector network analyzer was calibrated over the operational frequency range of the antenna. For the RLGA, a simple return loss measurement was performed.

A total of 2,010 (3×670 or 3 times mission thermal cycles) thermal cycles was performed. Visual inspection of the RLGA hardware did not show any anomalies due to the thermal cycling. The return loss measurement results of the RLGA antenna after the PQV (Package Qualification and Verification) test did not show any anomalies. The antenna pattern data taken before and after the PQV test at the uplink and downlink frequencies were unchanged. Therefore, the developed design of RLGA is qualified for a long-duration MSL mission.

This work was done by Rajeshuni Ramesham, Luis R. Amaro, Paula R. Brown, and Robert Usiskin of Caltech; and Jack L. Prater of Polytechnic High School for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48500

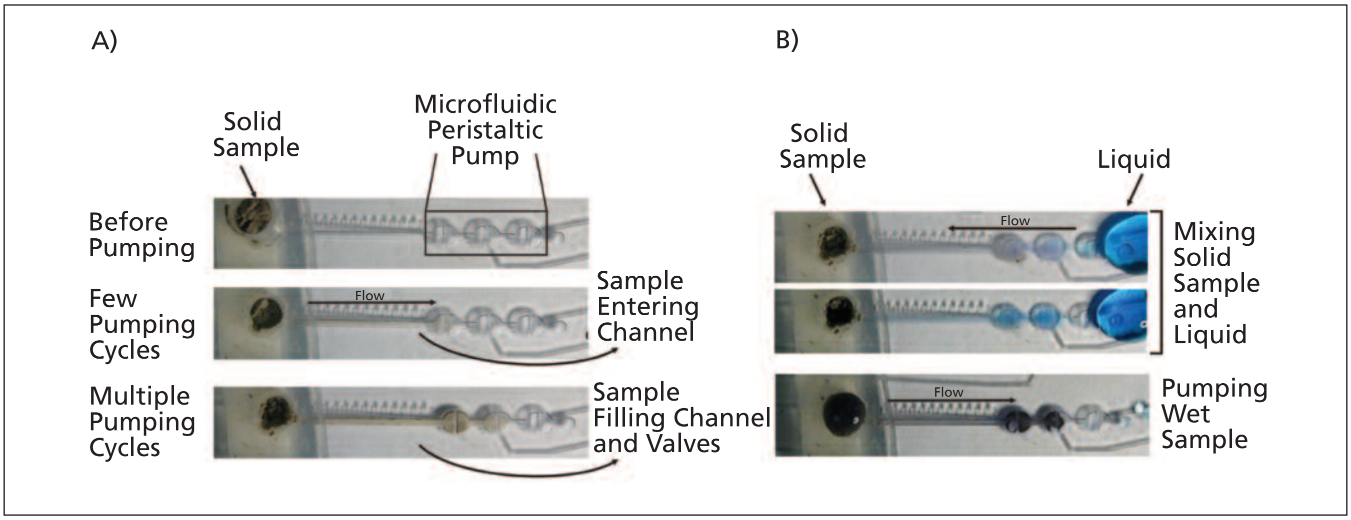
Automated, Ultra-Sterile Solid Sample Handling and Analysis on a Chip

This technique could be used in the pharmaceutical industry for the automated manipulation of small amounts of powdered drugs.

NASA's Jet Propulsion Laboratory, Pasadena, California

There are no existing ultra-sterile lab-on-a-chip systems that can accept solid samples and perform complete chemical analyses without human intervention. The proposed solution is to demonstrate completely automated lab-on-a-chip manipulation of powdered solid samples, followed by on-chip liquid extraction and chemical analysis.

This technology utilizes a newly invented glass micro-device for solid manipulation, which mates with existing lab-on-a-chip instrumentation. Devices are fabricated in a Class 10 cleanroom at the JPL MicroDevices Lab, and are plasma-cleaned before and after assembly. Solid samples enter the device through a drilled hole in the top. Existing micro-pumping technology is used to transfer milligrams of powdered sample into an extraction chamber where it is mixed with liquids to



(A) Manipulation of a **Solid Sample On-Chip**, and (B) mixing of fluid and solid sample on-chip. Each photograph is approximately 4×1 cm in size.

extract organic material. Subsequent chemical analysis is performed using portable microchip capillary electrophoresis systems (CE). These instruments have been used for ultra-highly sensitive (parts-per-trillion, pptr) analysis of organic compounds including amines, amino acids, aldehydes, ketones, carboxylic acids, and thiols. Fully autonomous amino acid analyses in liquids were demonstrated; however, to date there have been no reports of completely automated analysis of solid samples on chip.

This approach utilizes an existing portable instrument that houses optics, high-voltage power supplies, and solenoids for fully autonomous microfluidic sample processing and CE analysis with laser-induced fluorescence (LIF) detection. Furthermore, the entire system can be sterilized and placed in a cleanroom environment for analyzing samples returned from extraterrestrial targets, if desired.

This is an entirely new capability never demonstrated before. The ability to manipulate solid samples, coupled with lab-on-a-chip analysis technology, will enable ultraclean and ultrasensitive end-to-end analysis of samples that is orders of magnitude more sensitive than the ppb goal given in the Science Instruments, Observatories, and Sensor Systems Roadmap. This technology has potential applications for highly sensitive analyses of organic compounds elsewhere in the solar system, including Mars, Europa, Titan, and small bodies. It will also enable contamination-free analysis of returned samples. Finally, this could also be employed for a wide range of terrestrial applications including environmental, biomedical, or forensic analyses.

This work was done by Maria F. Mora, Amanda M. Stockton, and Peter A. Willis of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48603

Measuring and Estimating Normalized Contrast in Infrared Flash Thermography

Combining temperature contrast analysis with pixel intensity contrast analysis yields better results in characterizing void-like anomalies.

Lyndon B. Johnson Space Center, Houston, Texas

Infrared flash thermography (IRFT) is used to detect void-like flaws in a test object. The IRFT technique involves heating up the part surface using a flash of flash lamps. The post-flash evolution of the part surface temperature is sensed by an IR camera in terms of pixel intensity of image pixels. The IR technique involves recording of the IR video image data and analysis of the data using the normalized pixel intensity and temperature contrast analysis method for characterization of void-like flaws for depth and width.

This work introduces a new definition of the normalized IR pixel intensity contrast and normalized surface temperature contrast. A procedure is provided to compute the pixel intensity contrast from the camera pixel intensity evolution data. The pixel intensity contrast and the corresponding surface temperature contrast differ but are related. This work provides a method to estimate the temperature evolution and the normalized temperature contrast from the measured pixel intensity evolution data and some additional measurements during data acquisition.

Thermal simulation software, such as Thermo-Calc, provides simulation of surface temperature evolution on void-like flaws. A comparison of the experimentally estimated temperature contrast and simulation estimated temperature contrast is required to validate the simulation model and its input parameters. Conversely, if the simulation temperature contrast data is available, then a method provided here can be used to estimate the pixel intensity and the pixel intensity contrast based on known values of parameters of the data acquisition setup.

The normalized pixel intensity contrast and the normalized temperature contrast differ for objects with emissivity other than 1. Therefore, for better con-