Fiber-optic Micrometeoroid Impact Sensor for Future Lunar Exploration Missions

Jer-Chyi Liou, *Johnson Space Center*
Mark Burchell, *University of Kent*
Robert Corsaro, *U.S. Naval Research Laboratory*
Frank Giovane,
Virginia Polytechnic Institute and State University
Nick Lagakos, *U.S. Naval Research Laboratory*
Eugene Stansbery, *Johnson Space Center*

The NASA Orbital Debris Program Office has been developing several particle impact sensors since 2002. The main objective of this development is to eventually conduct in-situ measurements to better characterize the small (millimeter or smaller) micrometeoroid/orbital debris populations in the near-Earth environment. The Program Office also supports instrument development to define the micrometeoroid and lunar secondary ejecta (MMSE) environment for future lunar exploration activities. Data returned from future lunar MMSE in-situ measurements will benefit: (1) fundamental lunar science by providing key data to improve our understanding of lunar cratering processes and the growth, mixing, and transport of the lunar regolith; (2) lunar exploration applied science by providing an accurate MMSE environment definition of reliable impact risk assessments for human lunar exploration activities, designing cost-effective shielding for habitats, and developing mitigation measures to address dust contamination issues for critical instruments and robotic components; and (3) planetary science by providing accurate flux and size distribution of micrometeoroids to place constraints on theories of collisions among asteroids and evolution of comets in the inner solar system. A well-established link between micrometeoroid impacts and lunar regolith is also key to understanding other regolith-covered solar system bodies from remote-sensing data.

One of the MMSE instruments under project development is the fiber-optic micrometeoroid impact sensor (FOMIS). The project objective is to design and build prototype FOMIS units that can be assembled into a large-area (tens of square meters or more), low-cost, low-mass, and low-power-consumption MMSE impact sensor on the lunar surface. The basic components of FOMIS are a thin film, under tension, and multiple fiber optic displacement (FOD) sensors mounted near the surface. The FOD sensor (originally developed at the U.S. Naval Research Laboratory, Washington, D.C.) consists of seven optical fibers with the central fiber serving as a light-emitting diode transmitter and the other six fibers functioning as receivers. When a particle impacts or penetrates the thin film, it causes the film to vibrate like a drum. This vibration, which is a function of particle size and impact speed, is measured via the variation in intensity of the reflected light (figure 1). Due to the high sensitivity of the optical fibers, the measurable vibration amplitude is up to 1 cm with better than 1 Å resolution.

Successful hypervelocity impact tests on a prototype FOMIS unit demonstrated in early 2008 the feasibility of the system by using the two-stage light gas gun at the University of Kent (Canterbury, U.K.). Figure 2 shows the front and back of the 17-cm-diameter prototype unit and the setup inside the test chamber. The thin surface is a 25-µm-thick aluminized Mylar® film under tension; three FOD sensors are mounted on the back of the unit. Additional large prototype units, up to 78 cm across, with different shapes are being constructed and will be subjected to both low-velocity and hypervelocity impact tests in 2009.

The FOMIS project is funded by the Focused Investment Group of the Johnson Space Center Mission Enabling Science Program and the NASA Orbital Debris Program Office. Additional collaborators in the project include the U.S. Naval Research Laboratory, Virginia Polytechnic Institute and State University, and University of Kent (Blacksburg, Va.). The near-term goal of the project is to advance the maturity of the system to a technical readiness level of 6 by 2012, and identify any possible future lunar deployment opportunities.

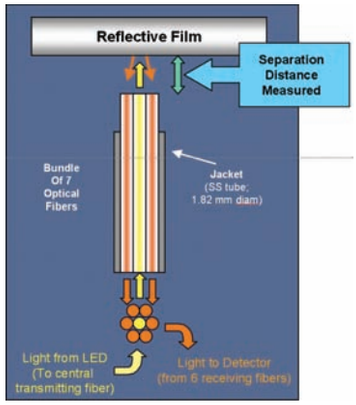

Fig. 1. *The concept used in FOMIS impact measurements.*

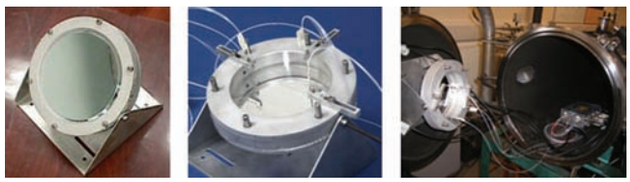

Fig. 2. *The front (left) and back (middle) views of a prototype FOMIS unit. The right image shows the unit and the electronics inside the two-stage light gas gun test chamber. Right before the closing of the chamber, the unit was turned 180 deg to allow the front side to face the incoming projectile.*

Click here for next report