LTC Laser Techniques Co.
Laser-based NDT and QC Systems

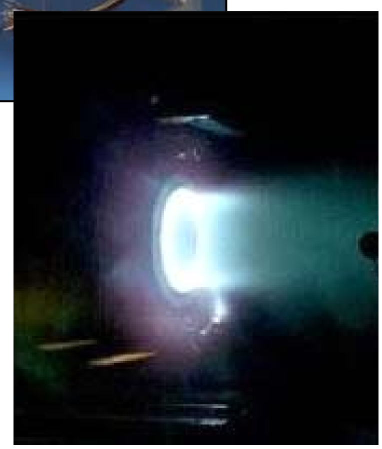
Application Notes

Laser mapping of erosion in Hall Thrusters

Hall thrusters are being developed for a variety of space vehicle positioning and deep space propulsion applications. The successful implementation of this new propulsion technology is expected to reduce typical fuel payloads by several hundred kilograms. At an estimated cost of $7,000 to $13,000 per kilogram of payload, Hall thrusters hold the promise of providing a cost-effective alternative to conventional chemical-based propulsion systems for maintaining satellite orbits and conducting deep-space exploration.

A critical factor that affects the long-term performance of these advanced propulsion systems is the integrity of the ceramic components used in the annular discharge chamber. Erosion on both the “inner” and the “outer” guard rings of the anode can cause ion beam divergence, which reduces overall performance and efficiency of the thruster — and can eventually lead to total mission failure.

NASA



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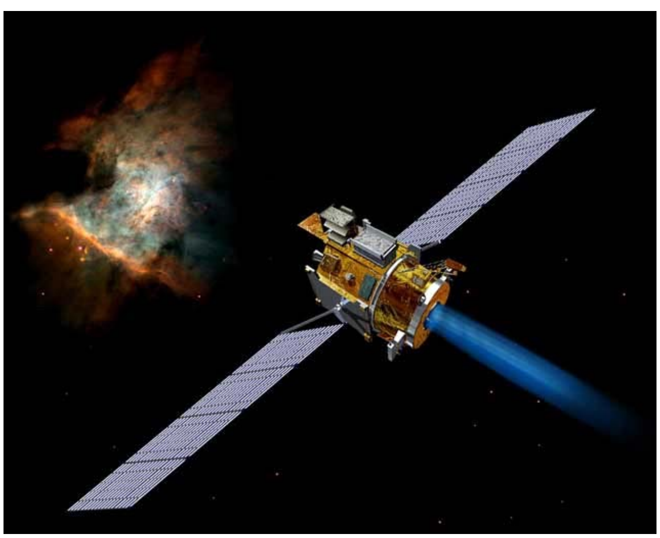


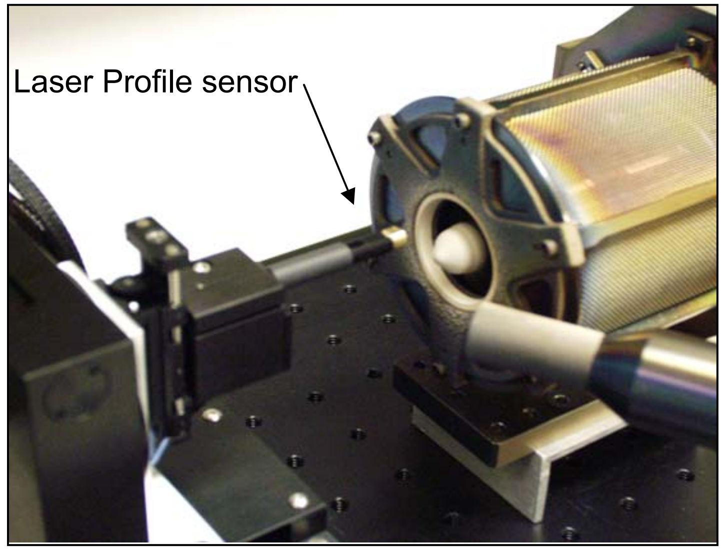
NASA

Monitoring and *quantifying* the erosion of experimental thrusters can be problematic. The confined annular space of the anode makes it difficult to measure the surface geometry using non-contact devices. Laser Techniques Company (LTC) was recently contracted by the US Air Force to adapt its automated *Laser MicroMap*™ system to provide three-dimensional, laser-based maps of both the conical “inner guard ring” and the cylindrical “outer guard ring” of a Hall thruster that is under development for a variety of applications.

Typical laser-based surface mapping systems project a line or spot onto the thruster surface from a large external source. Because of their size, these sensors are unable to map the internal surface of the guard rings, thus limiting the area of interrogation to the anode face and front corners. Employing a custom-designed miniature laser-based profiling sensor, the system developed by LTC is capable of reaching well into the annular cavity of the Hall thruster. Precision translation stages drive the sensor over the part surface, allowing virtually 100% of the anode surface to be mapped in a short period of time.

The images below show examples of a nearly pristine thruster. In these cases the data were sampled at a spacing of 0.001-inch (0.025 mm). The sensor linearity was confirmed to be better than 0.0002-inch (0.005 mm).

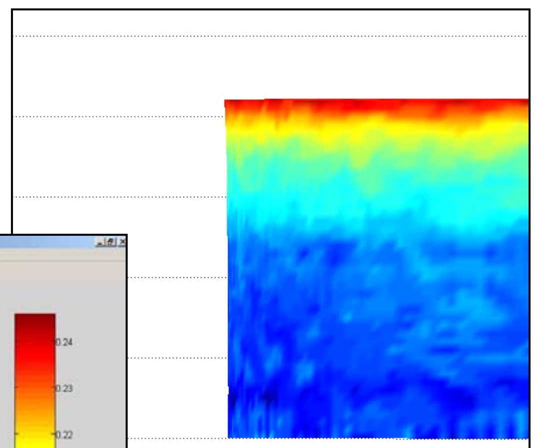
The three-dimensional data sets can either be interrogated using LTC's standard analysis software, or the data can be exported to scientific analysis and display programs such as MATLAB™.

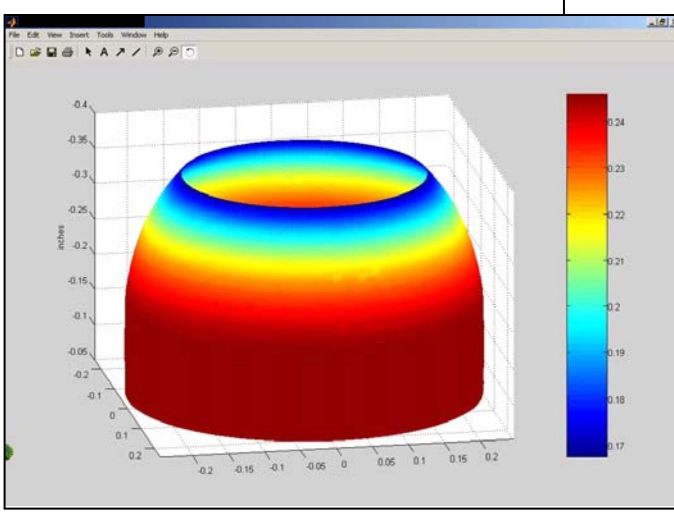


Laser Techniques Company, LLC

Outer Guard Ring (right)

Section view of surface.





Inner Guard Ring (left)

Full 360 degree scan of surface.

Preliminary System Specifications

Sensor

- Measuring range: 0.1 inch (2.54 mm) radial
- Linearity: 0.0002 inch (0.005 mm)
- Measurement resolution: 0.00005 inch (0.00127 mm)
- Sensor stand-off: 0.050 inch (1.27 mm)

3-Axis Sensor Delivery Unit

- Sampling resolution: 0.001 inch (0.025 mm)
- Motors and translation stages (Optional vacuum rated to 5×10^{-4} TORR)
- Axial travel: 2 inch (50.8 mm)
- Rotary stage travel: 360 degrees
- Radial translation stage travel: 0.25 inch (6.35 mm)

Data Acquisition and Reporting Software

LaserViewer™ software capable of:

- Multiple scan configurations - helical, raster, step/increment, etc.
- Acquiring and storing raw data
- Calibrating and post processing data
- Displaying calibrated results in plan, elevation and cross-section view
- Exporting raw or calibrated results in ASCII format

"LTC specializes in solving challenging measurement and inspection applications in a user-friendly and cost-effective manner."

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