



LVGEMS Time-of-Flight Mass Spectrometry on Satellites

This technology has applications in plant contaminant monitoring, clinical and medical diagnostics, and homeland security and defense.

Goddard Space Flight Center, Greenbelt, Maryland

NASA's investigations of the upper atmosphere and ionosphere require measurements of composition of the neutral air and ions. NASA is able to undertake these observations, but the instruments currently in use have their limitations. NASA has extended the scope of its research in the atmosphere and now requires more measurements covering more of the atmosphere. Out of this need, NASA developed multipoint measurements using miniaturized satellites, also called nanosatellites (e.g., CubeSats), that require a new generation of spectrometers that can fit into a 4x4 in. ($\approx 10 \times 10$ cm) cross-section in the upgraded satellites. Overall, the new mass spectrometer required for the new depth of atmospheric research must fulfill a new level of low-voltage/low-power requirements, smaller size, and less risk of magnetic contamination.

The Low-Voltage Gated Electrostatic Mass Spectrometer (LVGEMS) was developed to fulfill these requirements. The LVGEMS offers a new spectrometer that eliminates magnetic field issues associated with magnetic sector mass spectrometers, reduces power, and is about 1/10 the size of previous instruments. LVGEMS employs the time of flight (TOF) technique in the GEMS mass spectrometer previously developed at

Goddard Space Flight Center. However, like any TOF mass spectrometer, GEMS requires a rectangular waveform of large voltage amplitude, exceeding 100 V — that means that the voltage applied to one of the GEMS electrodes has to change from 0 to 100 V in a time of only a few nanoseconds. Such electronic speed requires more power than can be provided in a CubeSat.

In the LVGEMS, the amplitude of the rectangular waveform is reduced to about 1 V, compatible with digital electronics supplies and requiring little power. Thus, the LVGEMS concept makes possible very low power (< 0.5 W) mass spectrometers 1 to 2 in. (≈ 2.5 to 5 cm) in length; fitting and working well in CubeSats. With less voltage and power, there is also less risk of voltage breakdown at the spectrometer electrodes and less magnetic interference from the supporting electronics. Because of its small size, the LVGEMS can be part of an instrument suite, like the NASA/NRL WINCS (Winds-Ions-Neutral Composition Suite) that provides neutral and ion composition with other instruments providing the neutral wind, ion drift, and temperatures. Perhaps the main advantage of an instrument suite is that instruments like GEMS share electronics and power with other sensors,

thus minimizing the power consumed per spectrometer — another enabler for CubeSat missions for ionosphere-thermosphere science.

In an orbiting TOF spectrometer, measurements are difficult because all atoms and molecules species enter at the same velocity; therefore all incident atoms and molecules have the same TOF, making it impossible to differentiate between species. However, the newly developed LVGEMS mass spectrometer provides the ability to accelerate and add the same kinetic energy to all species, and this results in each species having its own unique TOF value for easy identification.

The principal feature of this invention is to enable TOF mass spectrometry in low-Earth-orbit investigations of the thermosphere at the time when new missions require multi-point measurements using large numbers of nanosatellites. LVGEMS offers a solution that requires no magnetic fields, no high-frequency voltages of high amplitudes, uses power less than 0.5 W, and has dimensions measured in a few cm (one inch or less).

This work was done by Federico Herrero of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16255-1

Surface Inspection Tool for Optical Detection of Surface Defects

The small, dual-picture tool enables both macro and micro views.

John F. Kennedy Space Center, Florida

The Space Shuttle Orbiter windows were damaged both by micrometeor impacts and by handling, and required careful inspection before they could be reused. The launch commit criteria required that no defect be deeper than a critical depth. The shuttle program used a refocus microscope to perform a quick pass/fail determination, and then followed up with mold impressions to

better quantify any defect. However, the refocus microscope is slow and tedious to use due to its limited field of view, only focusing on one small area of glass at a time. Additionally, the unit is bulky and unable to be used in areas with tight access, such as defects near the window frame or on the glass inside the Orbiter due to interference with the dashboard. Bulky camera equipment

was needed to acquire images for later processing and storage. The long depth of field of the refocus microscope provided crisp images of the defect, but didn't provide the user with a feel for depth of the defect since all parts of the image appear in focus.

The surface inspection tool is a low-profile handheld instrument that provides two digital video images on a com-