



Micro-XRF for *In Situ* Geological Exploration of Other Planets

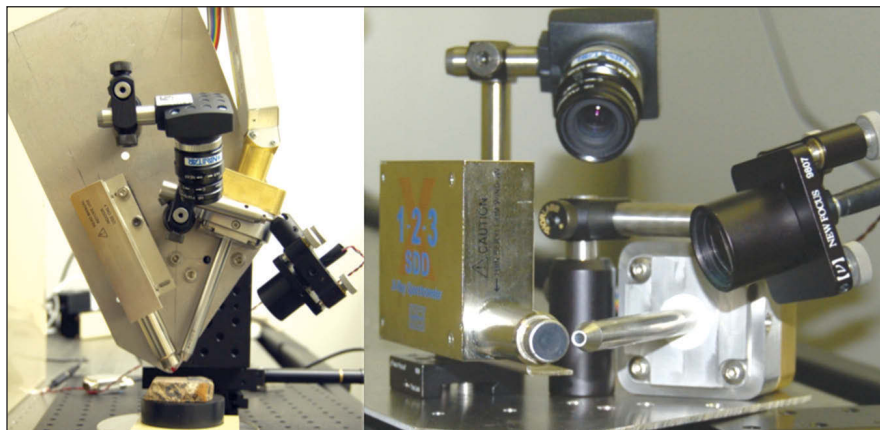
X-ray fluorescence instruments are used for non-destructive testing, sorting of recycled materials, and hazardous waste detection.

NASA's Jet Propulsion Laboratory, Pasadena, California

In situ analysis of rock chemistry is a fundamental tool for exploration of planets. To meet this need, a high-spatial-resolution micro x-ray fluorescence (Micro-XRF) instrument was developed that is capable of determining the elemental composition of rocks (elements Na–U) with 100 μm spatial resolution, thus providing insight to the composition of features as small as sand grains and individual laminae. The resulting excitation beam is of sufficient intensity that high signal-to-noise punctual spectra are acquired in seconds to a few minutes using an Amptek Silicon Drift Detector (SDD).

The instrument features a tightly focused x-ray tube and HVPS developed by Moxtek that provides up to 200 μA at 10 to 50 keV, with a custom polycapillary optic developed by XOS Inc. and integrated into a breadboard Micro-XRF (see figure). The total mass of the complete breadboard instrument is 2.76 kg, including mounting hardware, mounting plate, camera, laser, etc. A flight version of this instrument would require less than 5W nominal power and 1.5 kg mass.

The instrument includes an Amptek SDD that draws 2.5 W and has a resolu-



Two views of the breadboard **Micro-XRF Instrument**, which includes a Peltier-cooled detector with electronics, Moxtek HVPS, and x-ray tube integrated with an XOS polycapillary optic, a camera, and a focused laser.

tion of 135 to 155 eV FWHM at 5.9 keV. It weighs 180 g, including the preamplifier, digital pulse processor, multichannel analyzer, detector and preamp power supplies, and packaging. Rock samples are positioned relative to the instrument by a three-axis arm whose position is controlled by closed-loop translators (mimicking the robotic arm of a rover). The distance from the source to the detector is calculated from the position of a focused laser beam on the sam-

ple as imaged by the camera. The instrument enables quick scans of major elements in only 1 second, and rapid acquisition (30 s) of data with excellent signal-to-noise and energy resolution for trace element analysis.

This work was done by Lawrence A. Wade, Robert P. Hodyss, and Abigail C. Allwood of Caltech; Ning Gao of XOS; and Kris Kozaczek of Moxtek for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48599

Hydrogen-Enhanced Lunar Oxygen Extraction and Storage Using Only Solar Power

Oxygen-generating concept can be developed in an efficient system with low specific mass.

Marshall Space Flight Center, Alabama

The innovation consists of a thermodynamic system for extracting *in situ* oxygen vapor from lunar regolith using a solar photovoltaic power source in a reactor, a method for thermally insulating the reactor, a method for protecting the reactor internal components from oxidation by the extracted oxygen, a method for removing unwanted chemical species produced in the reactor from

the oxygen vapor, a method for passively storing the oxygen, and a method for releasing high-purity oxygen from storage for lunar use.

Lunar oxygen exists in various types of minerals, mostly silicates. The energy required to extract the oxygen from the minerals is 30 to 60 MJ/kg O. Using simple heating, the extraction rate depends on temperature. The

minimum temperature is approximately 2,500 K, which is at the upper end of available oven temperatures. The oxygen is released from storage in a purified state, as needed, especially if for human consumption.

This method extracts oxygen from regolith by treating the problem as a closed batch cycle system. The innovation works equally well in Earth or Lunar