AGU Fall Meeting, San Francisco, 12-16 December, 2016

P21C-2144: Microscopic Mapping of Minerals and Organics: A Modular Pulsed Raman Spectrometer Adaptable to Both Small and Large Landed Planetary Missions

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Raman spectroscopy combined with microscopic imaging is a powerful technique used to interrogate geological materials. In the laboratory, Raman spectroscopy is commonly used in the geosciences for mapping both major and minor mineral and organic constituents on a fine scale. This technique has proven valuable in analyzing planetary materials, including meteorites and lunar samples. By simultaneously analyzing microtexture and mineralogy, micro-Raman spectroscopy can provide essential information for inferring geologic processes by which planetary surfaces have evolved. Because Raman can perform these capabilities in a way that is non-destructive, requiring no sample preparation, it is extremely well suited for deployment on a planetary lander or rover arm. The pulsed Raman spectrometer presented here has been designed for maximum flexibility using miniaturized modular components in order to remain easily adaptable and relevant to numerous planetary surface missions (e.g. asteroids, comets, Mars, Mars' moons, Europa, Titan).

Building on the widely used 532 nm laser Raman technique, the pulsed Raman spectrometer takes advantage of recent developments in miniaturized pulsed lasers and detectors; the instrument uses sub-ns time gating to remove pervasive background interference caused by fluorescence inherent in many minerals and organics. This technique ensures acquisition of diagnostic Raman spectra, even in environments that have been known to severely challenge conventional methods (e.g. aqueously-formed minerals from similar environments on Earth). We present the architecture and performance of the pulsed Raman spectrometer, which relies on our single photon avalanche diode (SPAD) detector synchronized with our high-speed microchip laser, both custom-built for this application. It is these key technological developments that now make time-gated Raman spectroscopy possible for applications where miniaturization is crucial. We then discuss recent progress in laser performance that enhances Raman return, provides improved fluorescence rejection, and minimizes damage to sensitive samples.