Active and Passive Mid-Infrared Spectroscopy on Mars for In situ analyses and connection to remote sensing observation.
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Introduction: A critical science goal for future Mars missions is to characterize the surface mineralogy and any organic chemistry in the context of both past and present habitability. This goal is closely coupled with the identification and selection of rocks for a Mars Sample Return mission.

Bench-top laboratory mid-infrared Fourier transform spectrometers (FTIR) have long been the go-to tool for rapid, non-invasive characterization of samples across a variety of disciplines – from food security to geochemistry, FTIR has proven its utility for identification of both major and minor components within a sample. The mid-infrared region targets the strongest and most diagnostic vibration bands of many molecules and functional groups – the so-called spectroscopic “fingerprint region”.

Here we describe an instrument in development at JPL that provides active near- and mid-infrared spectra of surface samples, and which can also be used for passive solar reflectance near-IR and mid-IR thermal emission.

Three Spectrometers in One: The ideal infrared spectrometer for Mars surface analyses would provide the diagnostic capability of active mid-IR spectroscopy coupled with solar reflectance NIR and thermal emission spectroscopy that can be connected to measurements made from orbit, and from other regions on Mars (e.g. with CRISM and TES).

To address the missing link in current field and planetary science capabilities – i.e. the active mid-IR - we have constructed an active mid-infrared Fourier transform micro-spectrometer capable of analyzing mineralogy and organic chemistry of specimens in the field (Fig.1) [1, 2]. While of great utility for terrestrial studies, the instrument has also been designed with weight and power budgets in mind for potential use on future robotic missions to Mars.

The field device currently operates in the spectral range of 2.6 μm-15 μm and has a 4 cm^{-1} spectral resolution, but laboratory development is underway for a version that extends from ~0.9-20μm.

The spectrometer is coupled to a 15X microscope yielding a spatial resolution on the sample of approximately one millimeter. The detector system consists of a liquid nitrogen cooled HgCdTe and InSb sandwich detector. With a 12-second total integration time, the signal to noise ratio is 300, 1200, and 50 at 3.3 μm, 5.0 μm and 10.0 μm respectively. Spatial scanning and spectral images are made possible by two high-precision encoder-controlled motors that allow for motion in orthogonal directions. Maximum scanning range in both X and Y directions is approximately 2.5 centimeters.

We have used this spectrometer in the cold, dry climate of Antartica to work on the crypto-endolithic microbial communities within the Beacon sandstone of the trans-Antarctic mountains. A diverse set of both mineralogical and organic/biological spectroscopic features were easily identified with our instrument [1].

The Fourier transform (FTS) optics and detector array can be used for solar reflectance in the NIR and thermal emission at longer wavlengths. We are working toward coupling a mast-mounted optics train to the FTS such that solar reflectance NIR and thermal emission spectroscopy can be done on samples at a distance of many meters from a rover platform. With this added capability the same detector and spectroscopy optics bench will be able to perform three tasks in one – active NIR/MIR, passive solar NIR, and thermal emission. Such an instrument could be of great value for connecting critical local scale measurments from a rover to regional and global scale measurements made from orbit.

References: [1] Hand, K. P. et al. (2005) Proceedings of SPIE Vol. #5906. Optical Engineering and Instrumentation Instruments, Methods, and Missions for Astrobiology IX, 31 July- 2 August, 2005. [2] Anderson, M.S., et al. (2005) Fourier transform infrared spectroscopy for Mars science. Review of Scientific Instruments. 76: 034101.

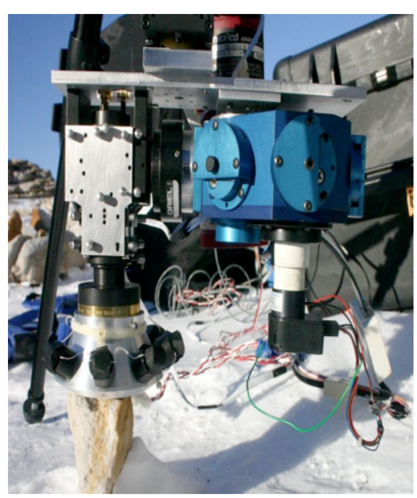

Figure 1. Our FTIR in the field in Antarctica. The rock is ~15 cm in height.