LUNAR INTERMEDIATE INFRARED IMAGING SPECTROMETER (LIIRIS) FOR MAFIC MINERAL COMPOSITION AND DIRECT H2O DETECTION.

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Introduction: The 4-8 µm intermediate infrared (IMIR) wavelength range has two unique capabilities that make it critical to study of the Moon. First, the Intermediate Infrared range uniquely enables both the identification of olivine [1] and pyroxene [2] and the quantitative determination of their Mg# using well-defined, mineralogically-diagnostic spectral bands that are unique to olivine and pyroxene. Second, the Intermediate Infrared wavelength range uniquely enables H_2O trapped in volcanic and impact-generated material to be directly detected and distinguished from OH, using the ~6.05 µm feature unique to H_2O. LEAG has therefore recently identified IMIR spectroscopy as a powerful technique for potential next generation continuous lunar orbital investigations [3].

Recent technological developments enable the design of small, high-fidelity instruments capable of measuring in this under-utilized wavelength range. We describe the design of the Lunar Intermediate Infrared Imaging Spectrometer (LIIRIS), which will measure emitted thermal radiation from the surface of the Moon to address fundamental science knowledge gaps related to the internal evolution of the lunar crust and the nature and distribution of H_2O of the Moon. LIIRIS will therefore provide geological context for potential sample return on Endurance-A, and knowledge about in situ resources for upcoming human exploration.

Science Background: Olivine has spectral bands at ~5.6 and ~6.0 µm that shift to lower wavelengths with increasing Mg# [1]. High-Ca pyroxene has Mg#-diagnostic spectral bands at ~5.1 µm and ~5.3 µm, and low-Ca pyroxene has an Mg#-diagnostic band at ~5.2 µm [2]. These pyroxene bands shift to shorter wavelengths with increasing Mg#, independent of Ca composition. The positions of the IMIR bands may be used to quantitatively determine Mg# of olivine and low-Ca pyroxene within ±10 mol%, and within ±23 mol% for high-Ca pyroxene. Meanwhile, H_2O has a fundamental vibrational band at ~6.05 µm unique to H_2O.

Instrument Design: The core of LIIRIS is an f/2.5 Dyson imaging spectrometer that enables a spectral range of 4-8 µm with 20 nm spectral sampling. Different telescopes can be used with different implementations of LIIRIS to tailor the spatial sampling and instrument field of view (FOV). The current telescope design allows a FOV of 35° with 2 mrad spatial sampling. The optical and opto-mechanical design of LIIRIS is based on the visible mid-wave Dyson imaging spectrometer (VMDIS) [4], a 0.6-3.6 um small form factor Dyson imaging spectrometer. The optical design will be updated to accommodate the novel wavelength range, including using ZnSe instead of CaF_2 for the lens material. LIIRIS will also implement an antimonide type-II superlattice (T2SL) detector with a customized cutoff wavelength of 8 µm, a breakthrough detector technology developed by JPL (Fig 1) [5,6]. T2SL detectors operate at higher temperatures, hence reducing the load on cryocooler and radiator requirements to allow a lower size, mass, and power solution. LIIRIS optical design combined with the customized T2SL detector, which itself will be paired an ISC0404 readout integrated circuit (ROIC) (Fig 1), will maintain low volume, mass, and power requirements while providing state of the art performance in terms of spectral/spatial uniformity. The spectrometer will use an electron-beam lithography fabricated grating, slit, and light trap developed by JPL that are of high-heritage from EMIT [7] and M3 [8].

For day-time lunar surface temperatures, the instrument will demonstrate signal-to-noise ratios of >300 [9], enabling successful Mg# determination within ±10 mol%, and detection of H_2O.

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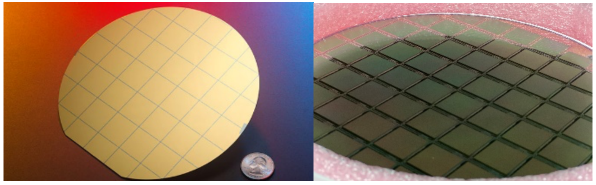

Fig. 1. (Left) Antimonide type-II superlattice (T2SL) wafer. (Right) FLIR 0404 ROIC wafer.