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MEMS BASED FABRY-PEROT INTERFEROMETERS FOR IN-SITU MATERIAL CHARACTERIZATION

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Rock forming minerals as well as organic compounds show distinguished spectral features in the mid (MWIR) and long wavelength infrared (LWIR) range that can be used to characterize extraterrestrial materials in-situ. In particular, silicates show the diagnostic Christiansen feature between 7.5 and 9 µm and Reststrahlenbands and Transparency features are located between 10 and 13 µm. Sulphates and Phosphates show features between 8 and 10 µm, while Carbonates can be identified around 11 µm. Organics can show features over the entire wavelength range between 5.5 and 13 µm. Thus, obtaining spectral information in the 5 to 13 µm wavelength range enables an extensive characterization of the material.

Mineralogical features are usually quite broad (> 0.5 µm), such that the spectral resolution requirements for such measurements are moderate and can be addressed by Fabry-Perot interferometers based on micro-electromechanical systems (MEMS). Existing technology can be tuned to central working wavelengths of 5 to 13 µm, but is not subject to fundamental limitations and the wavelength range could be extended if required. If working in the first interference order, the free spectral range of the MEMS interferometers is given by half the central wavelength, but for practical reasons is usually restricted to 1.5 µm and 3 µm for the short and

long wavelength ranges, respectively. Achievable spectral resolution is better than 50, i.e., at a central wavelength of, e.g., 10 µm the half-power bandwidth is about 200 nm.

We have developed a first prototype of a MEMS based Fabry-Perot interferometer using thermopile (single pixel) detectors. The instrument is based on flight-heritage radiometer technology as flown on, e.g., the Rosetta Lander, the Hayabusa2 MASCOT lander, and the Insight Mars lander. Sensors including thermopile detectors and a Fabry-Perot MEMS interferometer that is tunable in the 8 to 11 µm wavelength range have been integrated into standard transistor outline (TO) hermetic packages with a diameter of 15 mm and a height of 5 mm. Sensor housings have an aperture of 3 mm, the field of view of the sensor assembly is 20° full-width half-maximum, and the necessary control voltages for tuning the central wavelength is between 0 and 70 V. For flexibility, the order selection optical filter is currently external in our setup, but can later be integrated into the TO housing.

The current TRL of the sensors is TRL 4 and a functional verification of the setup has been performed under ambient conditions. Next steps for instrument development are tests under vacuum conditions as well as the development of a space qualifiable control circuit to generate the voltages needed for filter tuning. Overall, the instrument's sensor head is expected to weight less than 100 g and the total electronics mass is estimated to be 100 g without housing. The MEMS based Fabry-Perot concept can be extended to applications on orbiters and cube-sats by adding an entrance optics. Furthermore, using 2D imaging sensors, compact hyperspectral imagers for moderate spectral resolution applications can be realized.