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VISTA for DREAMS-ExoMars 2016

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Abstract

VISTA (Volatile In Situ Thermogravimetry Analyser) is the µ-thermogravimeter proposed for the DREAMS – Exomars 2016 module. It plans to measure dust and ice settling rate, physically adsorbed water in the dust and water frost point in the near-surface Martian environment.

1. Introduction

ExoMars 2016 is an ESA-led mission, to be launched by NASA, which plans to send to Mars an Orbiter and the EDM (Entry, Descent and Landing Demonstrator Module), which will land in the Mars Equatorial region and will work 4 sols [1]. DREAMS (Dust characterization, Risk assesment and Environment Analyser on the Martian Surface) is the scientific package proposed for the EDM and among the detector suite include the VISTA thermogravimeter [2].

µ-TGA (ThermoGravimetric Analysis) is a widely used technique to investigate deposition/sublimation and absorption/desorption processes of volatile compounds in different environments, e.g. outgassing contamination in Space and dehydration and organic decomposition in minerals [3,4,5]. The core of the µ-TGA is the Piezoelectric Crystal Microbalance (PCM), It converts mass in frequency variations following the Sauerbrey equation, which states that a mass variation is directly proportional to the change of frequency [6]. When the sample is heated, its most volatile component desorbs or sublimates: this allows to measure the mass of the volatile component (obtained as difference between mass before and after the desorption process respectively) and its composition (inferred by desorption temperature).

VISTA consists of a strongly miniaturised PCM equipped with a Thermo Electric Cooler (Fig. 1), which monitors its temperature. VISTA's sensible area is 0.1 cm^2, while the mass is 27 grams.

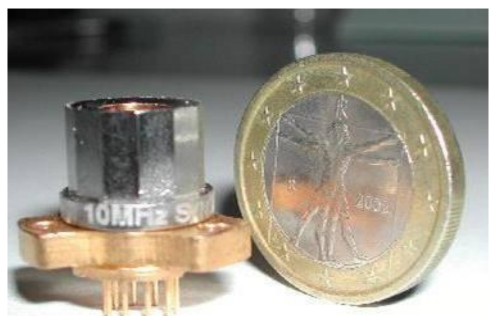

Figure 1: A miniaturised PCM that could be used for VISTA

2. The VISTA scientific objectives

VISTA would contribute to reach the following purposes, suggested in the ESA Announcement of Opportunity [1]: a) "Extend existing in situ datasets to help resolve discrepancies in remotely sensed data and models"; b)"Provide in situ experimental constraints on key physico-chemical properties and processes in the near-surface environment, with relevance to dust and water"; c) "Conduct measurements that can improve or complement the scientific outcome of the 2016 Trace Gas Orbiter and the 2018 Rover missions".

The VISTA scientific objectives are the following:

Dust settling rate. Dust mass loading has never directly measured on the Martian environment, but it has only predicted by synthetic models [7]. This is a measure of great interest, since is related to the future human exploration. VISTA would determine it by sampling periodically the sensor. It has been calculated that the PCM should not saturate, even in presence of dust storm [2].

Ice settling rate. Water ice fall has been detected at polar latitudes [8], but never at low latitudes (where DREAMS will land), although synthetic models suggests that this process could be possible. It should be noted that recently water ice on the surface has been revealed even at equatorial latitudes [9]. VISTA would reveal ice falls by applying a heating cycle few degrees above the water frost point, while the dust remains onto the crystal. This operation allows also the determination of the water frost temperature and (knowing the actual pressure) of the atmospheric humidity (next item). All these measures are important to study the habitability of Mars

Water frost point and humidity. VISTA would perform the first measurements of water vapor local abundance, while previous missions measured the column abundance. In case ice settling is not detected, water frost temperature is obtained by applying a cooling/heating cycle firstly to capture water molecule by frosting and successively to release them by sublimation.

Abundance of physically adsorbed water in the dust. Several authors suggest that the adsorption of water in the regolith may explain the diurnal variations in atmospheric water content (e.g. [10,11]). VISTA would give the first direct detection of water adsorption by solid grains on Mars. It is obtained by applying a heating cycle up to 240 K. The mass difference at the beginning and at the end of the cycle gives the adsorbed water mass.

3. VISTA operative modes

VISTA will operate in three modes: a) accumulation mode, i.e. passive collection of dust and ice; b) heating mode, i.e. warming up to the ice sublimation or adsorbed water desorption temperature; c) cooling mode, i.e. cooling down to the frost point of water and subsequently passive heating up to the environment temperature. During the night, the heating cycle is planned after the dust accumulation, to allow the deposited ice to sublimate. One time a sol, a cooling cycle is planned to measure the water frost point. After the cooling, the heater will be turned off and left warm up to the environment temperature. In the 4th sol, once a large amount of dust is present onto the microbalance crystal, a heating cycle to measure the adsorbed water in dust is started.

The total energy required for the whole mission is lower than 1.5 Wh and the total data rate is lower than 0.5 Mbit.

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