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VISTA thermogravimeter device for MarcoPolo-R

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Abstract

VISTA (Volatile In Situ Thermogravimetry Analyser) is a μ-thermogravimeter selected and currently under study for the ESA proposed mission MarcoPolo-R. It plans to monitor the sampling operations and to measure the water and organic content in the asteroidal regolith. Thermal and functionality tests on the VISTA breadboard are presented here, while the experimental tests are described in [1,2,3].

1. Introduction

MarcoPolo-R is a mission proposed in the framework of the ESA Cosmic Vision 2015-2025 program [4], and derived from a previously proposed mission called Marco Polo. It is a sample return mission from a Near Earth asteroid (NEA). The current target of the mission is 2008 EV5, a C-type NEA [5].
VISTA (Volatile In Situ Thermogravimetry Analyser) is a thermogravimeter developed by a consortium of Italian instituted, led by IAPS-INAF and it has been selected in response to the ESA AO for the payload and science ground segment elements for the M3 missions.
The instrument is based on micro-ThermoGravimetric Analysis (μ-TGA), a technique used to investigate deposition/sublimation and absorption/desorption processes in several fields (e.g. biologic, chemical, industrial) [6,7]. The core of the μ-TGA is a Piezoelectric Crystal Microbalance (PCM), whose oscillation frequency is proportional to the mass deposited on it, according to the Sauerbrey equation [8]. It is possible to heat the PCM, allowing the most volatile component of the analysed sample to desorb: mass and composition of the volatile can be inferred by the frequency change and by desorption temperature, respectively.

In the MarcoPoloR mission scenario the VISTA scientific role is two-fold:

- *Measure the volatile content (water and organics) in the asteroid regolith*
- *Measuring the regolith dust raised during the sampling procedures*

2. Instrument concept and design

VISTA consists of a heated $GaPO_4$ crystal microbalance and its proximity electronics. The crystal includes a built-in heater and a built-in temperature sensor (thermistor), placed onto the opposite faces of the microbalance. This special design dramatically reduces the total mass and the power required to perform thermal cycles [9].
VISTA will be able to detect the dust raised by the sampling procedure. Once the regolith dust has been collected high temperature μTGA measurements will be performed. In particular, temperatures of 320-420 K will be reached to allow the physically adsorbed water to desorb, whereas at 470-570 K decomposition of organics should occur and at higher temperatures desorption of surface-bound water and decomposition of carbonates are expected [10-13].
Each sensor has its own proximity electronics, including the frequency counter and the temperature control system of the microbalance, as well as a serial bus for the data transmission.
The main electronic board is in common with other sensors and should include: a) a DC-DC converter, to transform the voltage supplied by the S/C (i.e. 28 V) in 12 V, 5 V, 3.3 V voltages; b) an A/D converter, to transform the analogic signal coming from sensor unit into digital signals; c) a memory to store the data; d) a serial bus interface to transfer data to the elaboration unit or other units in the S/C.

The VISTA block diagram is shown in Fig. 1, whereas the technical characteristics of the sensor are summarised in Table 1.

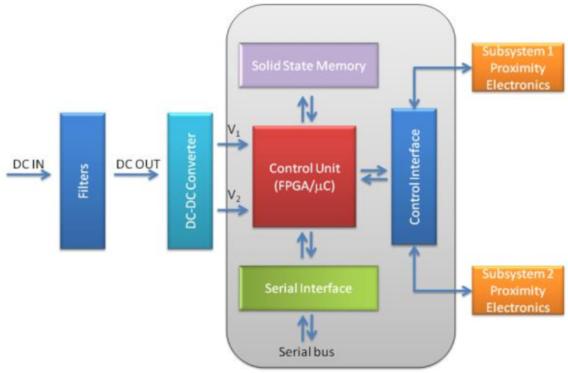

Figure 1. VISTA block diagram

Mass (g)	25
Area (cm^2)	0.1
Operating temperatures (K)	250-750
Power (W)	0.5 (mean) 2 (peak)
Data rate (bit/sampling)	30
TRL	4-5

Table 1. Technical characteristics of the VISTA PCM

3. Tests

3.1 Thermo-mechanical analysis

Thermal tests have been aimed to: a) define a mechanical configuration which guarantees a temperature distribution on the electrode area as uniform as possible; b) characterise the heater, in order to know its resistance and its temperature when a certain power is supplied.
We found that the symmetrical configuration with three mechanical supports placed at 120° would be the best one to reduce thermal uniformity on the measurement area (maximum temperature difference within the electrode area is 15 K).
Both the heater resistance and temperature linearly depend on the supplied power, as shown in Fig. 2.

3.2 Functionality tests

PCM frequency does not depend only on the deposited mass, but can be subjected to variations due to instability, temperature or pressure change. Before to perform measurements (described in [1-3]), these behaviors have been predicted by means of functionality tests in order to disentangle mass from environmental parameters effects on frequency variations .
It has been found that frequency increase at increasing temperature according to a 3rd degree polynomial, whereas is stable at fixed temperature. A frequency decrease at increasing pressure has been observed, too.

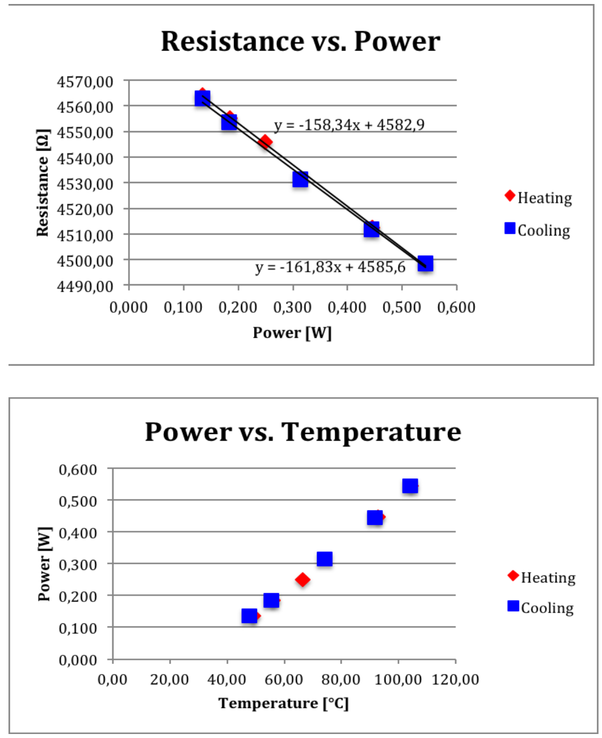

Figure 2: Heater resistance as function of power supplied (above) and power supplied as function of heater temperature (below) for measurement performed in vacuum.

References

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