VISTA instrument: a miniaturized Thermogravimeter concept for volatiles and dust characterization in planetary environments E. Palomba[1], F. Dirri[1], A. Longobardo[1], D. Biondi[1], A.Boccaccini[1], A. Galiano[1], E. Zampetti[2], B. Saggin[3], D. Scaccabarozzi[3], J. M. Torres[4]
[1]IAPS-INAF, Via Fosso del Cavaliere 100, 00133 Rome, Italy (ernesto.palomba@iaps.inaf.it, fabrizio.dirri@iaps.inaf.it, andrea.longobardo@iaps.inaf.it), [2]IIA-CNR, via Salaria km 29,300 Monterotondo, Rome (e.zampetti@iia.cnr.it); [3]Politecnico di Milano, Polo Territoriale di Lecco, Lecco, Italy (bortolino.saggin@polimi.it, diego.scaccabarozzi@polimi.it); [4] Luleà University of Technology (Javier.martin-torres@ltu.se)

Introduction: VISTA (Volatile In Situ Thermogravimetry Analyser) is a μ-Thermogravimeter device, developed by a consortium of Italian institutes (IAPS-INAF, IIA-CNR and Politecnico di Milano). The concept of the instrument is based on a Piezoelectric Crystal Microbalances (PCM) whose resonant frequency linearly depending on the mass deposited on its sensible area according to Sauerbrey equation [1]. The PCM can be heated or cooled by means of integrated heaters allowing the ThermoGravimetric Analysis (TGA), i.e. a technique used to monitor deposition/sublimation and absorption/desorption processes [2],[3] involving volatile compounds. Thus, the μ-TGA can both measure the water and organics desorption, whose presence is connected to habitability of the planet/satellite and to monitor outgassing contamination in space, too [4].

VISTA is composed by two sensor heads, VISTA1 (SiO_2-based microbalances) and VISTA2 ($GaPO_4$-based microbalance). Each microbalance is equipped with a built-in heater and a built-in temperature sensor on each crystal face and the related Proximity Electronics (PE). The temperature of VISTA (which needs a small amount of material for analysis, i.e. less than 1 mg) can be increased in order to allow sublimation/desorption of the most volatile component while the mass and composition of the volatile can be inferred by the frequency change and by desorption temperature, respectively.

In order to obtain a physical-chemical characterization of the volatile species, it is possible to infer some physical-chemical parameters, e.g. enthalpy of sublimation/evaporation $\Delta H_{sub,evap}$, despsotion and sublimation rates on the crystal surface (at a given temperature and pressure), during the deposition and TGA thermal processes [3].

Applications: VISTA instrument has been studied for planetary and space applications and proposed for planetary in-situ missions [6]. VISTA has been selected in the payload of the ESA MarcoPoloR mission study [7] and has been studied, e.g. on Europa and Ganimede [8] and on Mars [9]. An application for VISTA SH1 is currently under study for materials outgassing and deposition kinetics characterization of materials for on-ground uses.

The main tasks achievable by VISTA and depending to the planetary environment are:

- measurement of abundance of volatiles of scientific interest (e.g. water, organics) in planetary/asteroidal regolith and cometary-like activity (MarcoPolo-R mission);
- measurement of dust and ice settling rate, water content in dust and humidity (Mars);
- discrimination between water ice and clathrate hydrates on icy satellite surfaces;
- measurement of the abundance of organic compounds present as nucleating seeds within Titan cloud particles (acetylene, benzene, HCN);
- measuring the contaminants deposition from outgassing materials in space, obtaining the contaminants (volatiles and refractory materials) characterization by using TGA technique;
- measurement of atomic oxygen erosion which can cause the degradation and oxidation of sensitive materials;
- characterization of organic species by measuring its sublimation rates and enthalpy of sublimation.

VISTA technical characteristics: VISTA is composed by two different subsystems:

- *Sensor Head 1 (SH1):* able to work at low temperaures (down to -200°C) and to perform thermal cycle up to 100°C for the contaminant molecules detection coming from outgassing processes;
- *Sensor Head 2 (SH2):* able to performs TGA measurements (large temperature range, i.e. >200°C) with a low power budget, analyzing water and organics contents inside planetary regolith.

Currently, an Engineering Model has been developed for VISTA SH1, TRL 6 (Fig.1), while a laboratory breadboard of SH2 has been developed, too and it is under testing (TRL 4-5).

*Fig.1***.** VISTA SH1 Engineering Model, i.e. *Quartz Crystal Microbalances*-based instrument.

Tab.1 shows as VISTA has a very small mass, volume and power requirements. The Proximity Electronics (PE) is included in the sensor head while the Main Electronic (ME) can be shared with other devices of the scientific package, reducing the total weight of VISTA.

Unit	*SH1*	*SH2*
Sensor type	*Quartz Crystal Microbalance*	*$GaPO_4$ Crystal Microbalance*
Resonant Frequency(MHz)	*10*	*5.8*
Mass [g]	*90*	*60*
Volume [mm]	*50x50x38*	*35x35x25*
Power [W]	*1 W (peak); 0.12 (mean)*	*0.62 (peak); 0.37 (mean)*
Data rate	*30 bit/ measurement*	*30 bit/ measurement*
Operating Temperatures [K]	*< 180*	*< 550*
TRL	*6*	*4/5*

Tab.1 VISTA technical characteristics.

Tests: VISTA SH1 Breaboard and Engineering Model have been validated by detecting contaminant materials at -20°C in vacuum with deposition, saturation and TGA tests (Fig. 2) while VISTA SH2 Breadboard has been used to characterize pure organic compounds (belongs to carboxylic acid class) at -80°C in medium vacuum condition [3].

In order to characterize each contaminant and organic compounds by means of deposition tests and TGA cycles, the enthalpies of sublimation (*ΔH_{sub}*) have been obtained by using Langmuir and Clausius-Clapeyron relations [10].

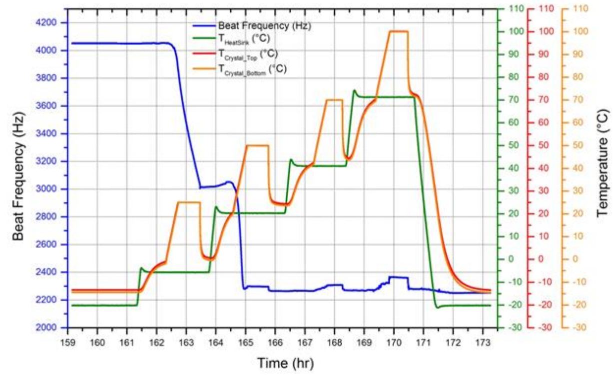

Fig.2. Different TGA cycles after a contamination test performed at -20°C. The crystals temperature was increased by means of the integrated heaters at +25, +50, +70 and +100°C. The material desorption (~2kHz) was mainly obtained during the first two heating steps.

The obtained results for SH1 are in agreement within 5% with literature [11] and show the good capability of VISTA SH1 to characterize a contaminant material.

Furthermore, the results obtained with SH2 for organics characterization are in good agreement with literature [11], [12], [13] demonstrating the VISTA SH2 capability to measure *ΔH_{sub}*.

References

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