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MOVIDA, a microbalance system to measure volatile content and charging processes of lunar dust

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Abstract

In this paper the MOVIDA instrument is presented, a micro-thermogravimeter (light, small and low-power consuming) able to perform key in-situ measurements in the Lunar environment (i.e. water and organics amount in the dust, water ice detection, charge-to-mass ratio of dust grains).

1. Introduction

The MOVIDA (MOon Volatile Investigator and Dust Analyser) instrument here presented is being developed by a consortium of institutes, leaded by IAPS-INAF. It plans to characterise the lunar environment and potential in situ resources to identify their implications for future human exploration. MOVIDA main scientific objectives are:

- measure the volatile content in the lunar dust (i.e. water, organics and carbonates);
- detect the possible presence of water ice;
- measure the electrical properties of the lunar levitating dust (i.e. charge-to-mass ratio).

Measurement of water and organic-rich materials is extremely important to understand what kind of resources can be available to humans on the Moon and what kind of processes act to originate and/or destroy Lunar volatiles.

The study and characterization of the lunar dust charging and levitation has significant implications both from the scientific point of view and for enabling future long-duration human lunar missions. During the Apollo missions it was noted that lunar dust (with diameter less than 20 μm) easily entered the cabin after astronauts Extra Vehicular Activity, creating several problems both to crew safety and instrumentation [1].

2. Working principle

MOVIDA is based on an array of micro-oscillators whose detecting part is made up of piezoelectric crystals with a conductive electrode that acts as a collector of micron and sub-micron size particles.

Piezoelectric crystal microbalances (PCMs) are one of the most widely used chemical sensors in gas/particle sensing for space and in environmental and biological applications [2,3].

These sensors convert mass changes into fundamental resonance frequency variations, according to the Sauerbrey equation [4]. The PCM temperature can be increased in order to allow the most volatile component of the analysed sample to desorb. This process, called μ–Thermogravimetric analysis (μ–TGA), allows to infer the abundance of the desorbed volatile compound (from the mass variation) and its composition (by measuring its sublimation temperature and its enthalpy of sublimation [5]).

An important challenge of MOVIDA is the presence of a built-in heater and a built-in thermistor integrated onto the crystal. This special design dramatically reduces the total mass and the power required to perform thermal cycles.

Another innovation introduced by MOVIDA consists in the development of a new generation of microbalances able to attract charged dust grain by means of a variable Electric Field (EF), generated locally by the instrument itself. The application of this EF will break the equilibrium between the Electric and the Gravity Fields on the Moon (predicted by Levitation model, e.g. [6]), allowing the electrically charged dust grains to be attracted toward the microbalance (Figure 1). The electric charge accumulated onto the sensor will be measured by a capacitors cascade, using the capacitors discharge principle.

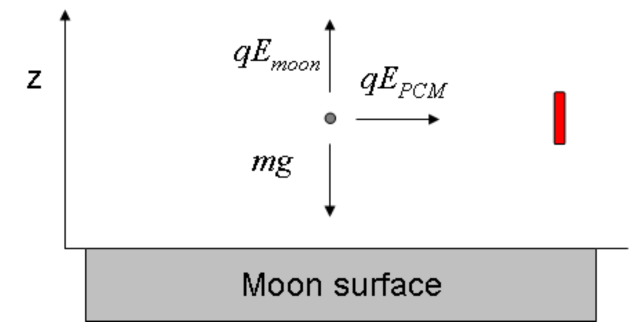

Figure 1: Dust deposition on the PCM (in red) when an electric field (E_{PCM}) is applied

3. Instrument concept and goals

MOVIDA requires low mass, low size and is low power-consuming. Its technical characteristics are summarized in Table 1.

Mass	<500g
Volume	< 300 cm^3 (main electronics & sensing system included)
Average data rate	0.5 kbps
Average required power	< 2 W

Table 1: MOVIDA technical characteristics

The instrument is composed by four units:

- *Unit 1*, i.e. the electronic box;
- *Unit 2*, i.e. a thermal PCM, aimed at measuring the volatile abundance in the lunar dust. PCM should be heated up to 280-330 K, 500-750 K and above 750 K to allow desorption of water, organics and carbonate respectively [7,8,9,10]. The water abundance expected depends on grain size, latitude, local time and composition. It varies from 10 ppm [11] to 3000 ppm [12]. Even if the water content was less than the MOVIDA detection limit (i.e. 100 ppm), the performed measurements would help to constrain some physical parameters, i.e. grain size.
- *Unit 3*, i.e. a cryogenic PCM aimed at detecting water ice by heating it up to the ice sublimation temperature, i.e. 160 K.
- *Unit 4*, i.e. a PCM placed inside a capacitor held at a voltage *V*. Dust particles passing through the capacitor will deposit on a PCM in a time depending on their charge-to-mass-ratio (Figure 2).

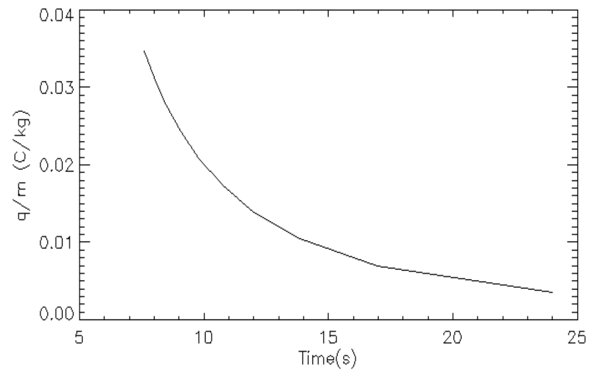

Figure 2. Time of deposition on PCM of lunar dust particles having different charge-to-mass *q/m* ratioes, for *V*=1 V. The assumed dust particle size is 200 nm, as predicted by the Dynamic Fountain Model [13].

4. MOVIDA current status

The technical concepts of MOVIDA benefit of developments already performed for the VISTA (Volatile In Situ Thermogravimetry Analyser) instrument, studied and selected for the scientific payload of the ESA MarcoPolo-R mission study [14]. VISTA is a miniaturised thermogravimeter, equipped with built-in heater and thermistor, able to perform measurements of the volatile compounds (water and organics) adsorbed onto the asteroid regolith.

The technology of MOVIDA is mature and has been demonstrated on different planetary missions. The new improvements, consisting in measuring electric charge by capacitor discharge and in capturing charged particle by means of a controlled Electric Field, are demonstrated in their basic principles.

References

[1] Taylor L. A. et al. (2005) *1st Space Explor. Conf., AIAA*; [2] Wood B.E. et al. (1996), *Proc. SPIE* 2864, 187-194. [3] Palomba E. et al. (2002), *Adv. Spa. Res.*, 29, 8, 1155-1158; [4] Sauerbrey G. (1959), *Z. Phys.*, 155, 206-222; [5] Dirri, F. et al. (2014), *EPSC 2014*, session MTI8; [6] Wang, J. et al. (2008), *IEEE Transactions on Plasma Science*, 26, 5, 2459-2466; [7] Grady, M.M.; et al. (2002), *Met. Planet. Sci.*, 37, 713-735; [8] Sephton, M.A. et al (2002), *Nat. Prod. Rep.*, 19, 292-311; [9] Halbout, J.. et al (1986), *Earth and Planet. Sci. Lett.*, 80, 1-18; [10] Bruckenthal E. A. and Singer R. B. (1987), *LPSC Abstracts*, 18, 135; [11] Clark R.N. et al. (2009), *Science*, 326, 562-564; [12] Sunshine J.M. et al. (2009), *Sciencexpress*, doi: 0.1126/science.1179788; [13] Stubbs T.J. et al. (2006), *Adv. Spa. Res.*, 37, 1, 59-66; [14] Palomba E. et al. (2013), *EPSC 2013*, 619.