EPSC Abstracts
Vol. 10, EPSC2015-865, 2015
European Planetary Science Congress 2015

The Micro Imaging and Dust Analysis System – New Possibilities for Space Sciences

R. Schmied (1), K. Torkar (1), H. Jeszenszky (1), J. Romstedt (2), T. Mannel (1), M.S. Bentley (1) and the MIDAS Team (1)
(1)Institut für Weltraumforschung, Graz, Austria, (2) European Space Research and Technology Centre, Future Missions Office (SREF), Noordwijk, Netherlands

Abstract

The Rosetta mission addresses a range of fundamental questions in Solar System and cometary science and the MIDAS instrument on-board the orbiter is one of the dust analysis systems. While GIADA analyses the dust flux and spatial distribution as a function of time and space and COSIMA investigates the elemental composition of cometary grains, MIDAS is a unique high resolution Atomic Force Microscope (AFM) combined with a dust collection and handling system designed to reveal the three-dimensional topographical structure of nano- and micrometer sized dust particles [1]. In this work we concentrate on the instrumental functionality and limitations coming from the constcution and operation dealing with an AFM fabricated nearly 20 years ago and operating in a harsh environment.

1. Introduction

The technique of Atomic Force Microscopy was first published in 1986 by Binnig, Quate and Gerber [2] and was thus a very new technique at the time Rosetta was designed and MIDAS was proposed. The most important advantage compared to other surface characterization methods is the quantitative 3D information down to spatial nm resolution. Also the ease of sample preparation and its non-destructive character make AFM a perfect instrument for *in-situ* particle analysis. Due to the development of additional measurement modes, the available information goes beyond surface morphology and includes mechanical, electrostatic, chemical, electronic and magnetic properties. This additional information can often be acquired in a simultaneous manner. Beside morphological investigation, MIDAS is also designed to reveal the magnetic properties in the micro- and nanometre range.

2. The Micro Imaging and Dust Analysis System

MIDAS had to be designed to survive and operate with several environmental influences, such as launch vibrations, the intrinsic temperature variations in space and the vibrational loading during manoeuvres which cause problems for an AFM which is very sensitive to vibrations. The cantilever system in combination with the tip geometry is of particular importance, since it is responsible for the sensitivity of the microscope. On the one hand a robust cantilever will withstand all these influences, but as present-day developments show, a multitude of cantilever designs are available for specific purposes. Since MIDAS was developed 20 years ago and the fabrication technique was not that well developed some differences are shown compared to the well adapted designs.
In the second part the possibility of imaging beyond the morphology will be discussed, including mechanical information and magnetic properties, which are of particular interest for Rosetta. A comparison the state-of-the-art AFM developments will be shown, which may indicate new possibilities for future flight instruments.

Acknowledgements

We gratefully acknowledge funding from the Austrian Academy of Sciences and the Austrian Research Promotion Agency (FFG).

References

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