In situ nanometre imaging of cometary dust with the MIDAS atomic force microscope

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Abstract

The MIDAS instrument onboard Rosetta [1] will offer the first ever 3D nanometre to micrometre in situ images of cometary dust particles and aggregates on arrival at comet 67P/Churyumov-Gerasimenko in 2014. By using the principle of atomic force microscopy MIDAS (Figure 1) will non-destructively image particles collected on 61 targets, exposed over a range cometary and heliocentric distances.

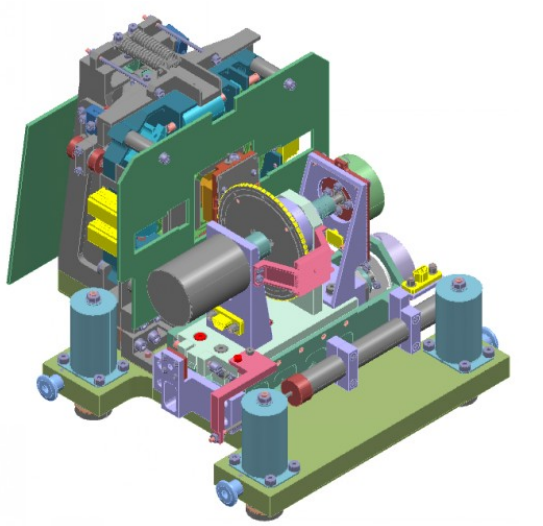

Figure 1: The internals of the MIDAS instrument.

As well as providing basic imaging and particle morphology, MIDAS aims to extend characterisation of the integrated dust flux below the size limits available to other instrumentation. Several tips are also magnetised, allowing any ferromagnetic minerals to be identified and mapped.

MIDAS collects dust by exposing individual targets for periods of hours, weeks or months, depending on the level of cometary activity. Dust flux models are used in the first instance to calculate the exposure times necessary to give appropriate coverage. Exposed targets can then be scanned by one of sixteen cantilevers with a lateral resolution of up to 4 nm, and up to ~0.2 nm in height.

MIDAS does not have an associated optical microscope and so the first challenge is to locate particles suitable for high resolution scanning. A second challenge is ensuring that the force exerted on the sample by the vibrating tip is minimised to non-destructively image potentially fragile sample.

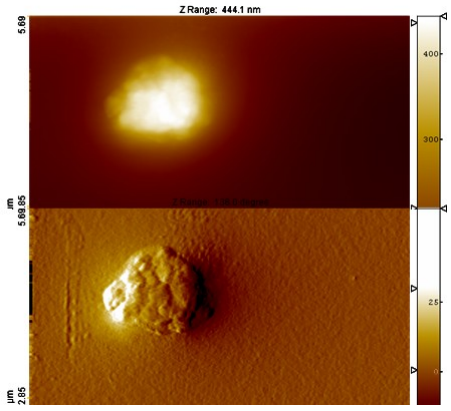

Figure 2: A topographic (top) and phase (bottom) MIDAS scan of a micron sized calcite particle.

During the 10 year cruise phase, a campaign of measurements (using the flight spare) and numerical modelling has and is being undertaken to optimise the measurement procedure and prepare for the cometary encounter. This includes imaging of a variety of materials, for example the calcite sample shown in Figure 2.

Here we will first review the scientific goals and operating procedures of the MIDAS instrument, and show some of the latest results of the ground campaign.

Finally, although MIDAS was the first space-borne AFM to be built, the Mars Phoenix microscope has the privilege of being the first to operate off-Earth. Despite the comparatively different design of the two instruments, their commonalities are sufficient to begin a useful dialogue on the science and operation of such instruments.

References

[1] Riedler, W. et al. (2007) *Space Science Reviews,* 128, 869-904.