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Raman analyses of *Stardust* terminal grain in Track 170.

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Abstract

We present initial Raman spectroscopy results from the terminal grain of track 170 in keystone C2112,4,170,0,0 taken from the cometary side of NASA's *Stardust* mission sample collector [1]. Results are compared to the mineralogy described by Bridges *et al* [2] from XANES and EXAFS analyses.

1. Introduction

In order to maximise the scientific return from the unique sample set returned by NASA's *Stardust* mission, it is vital that analyses of the samples are initially undertaken using as many different, non-destructive, techniques as possible - preferably on particles whilst they are still embedded in aerogel.

Previous *in situ* XANES and EXAFS analyses carried out on the terminal grain of track 170 (the keystone is shown in Figure 1) concluded that the terminal grain contained a mixture of Fe-metal and Cr- and Ca-bearing silicate [2]. However, as these techniques are insensitive to Mg, and the encasing aerogel prevents a quantitative Si abundance from being determined, no definitive identification of the silicate component could be made. Raman spectroscopy is capable of uncovering the mineralogy of silicates, and has been used previously to analyse *Stardust* cometary grains [3]. Since aerogel is largely transparent to the exciting Raman laser, we were able to examine the grain *in situ*, with the aim of confirming the previous findings and uncovering the nature of the silicate phase.

2. Experimental methodology

We have used a new state-of-the-art Raman spectrometer recently installed at the University of Kent to study the terminal grain of *Stardust* track 170. This spectrometer (a *LabRam-HR* from Horiba) incorporates three lasers: NIR (785 nm), red (633 nm) and blue (473 nm). It has Stoke and anti-Stokes filters, polarisers and temperature stages which enable spectra to be obtained in the temperature range 77K – 1800K. The maximum laser power at the sample is 30 mW, but here a 10% neutral density filter was used at all times which limited the power at the sample (through a ×50 objective) to a maximum of ~3 mW, thus avoiding unwanted heating and possible modification of the grain [4]

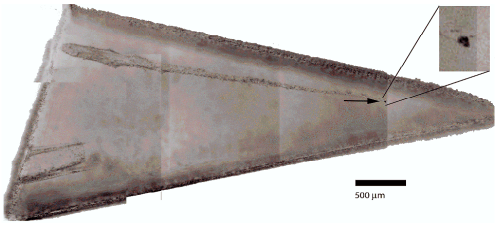

Fig. 1: Aerogel keystone showing location of terminal grain. The grain is approximately 20 microns in diameter and located ~140 microns below the surface of the aerogel.

Upon receipt, the keystone was carefully unwrapped and photographed prior to loading in the spectrometer (Figure 2). The keystone had been mounted on kapton tape and partially covered by a thin, transparent, mylar film. The kapton tape proved to be strongly fluorescent in all available laser lines, and was particularly problematic with the NIR laser. The fluorescence was minimised by using the confocal aperture on the spectrometer to control the interaction volume: A smaller confocal aperture samples a smaller volume of sample, but gives a reduced signal. By reducing the aperture size to a diameter of 200 microns, the vast majority of the background fluorescence was eliminated, enabling the successful acquisition of a Raman spectrum using the 633 nm laser with an integration time of 30 seconds. Thirty such integrations were averaged to give the spectrum shown in Figure 3 (red line).

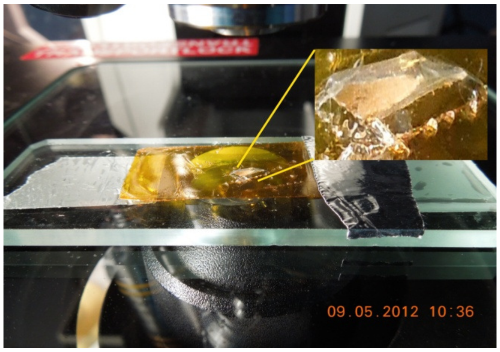

Figure 2: The keystone sample in its 'as received' condition just prior to loading in the spectrometer. The yellow film is kapton tape and the aerogel keystone is covered in a mylar tape (insert).

3. Results and Discussion

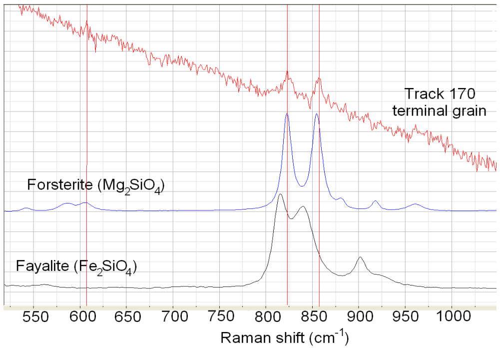

Figure 3: Raw Raman spectrum of terminal grain (red) compared to the Mg and Fe-rich olivine end-members forsterite (blue) and fayalite (black). Note that the two spectral peaks for the terminal grain closely match those of forsterite.

Two peaks located at 824 and 856 cm^{-1} were observed in the Raman signal from the terminal particle (Figure 3, top red line). These peaks are best fit by the Mg-rich olivine end-member (forsterite) indicating (at least) that the surface of the grain contains a small component of forsterite.

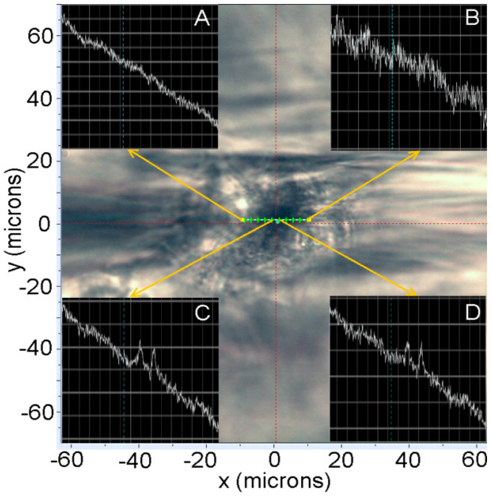

Figure 4: Line map across the terminal grain. Figures A and B are spectra taken from the left and right hand edges of the grain, and C and D from the centre. All spectra show the underlying fluorescence caused by the kapton tape, but only C and D show spectral features at 824 and 856 cm^{-1}.

These results therefore confirm that the terminal particle contains some silicate as proposed by [2]. However, bearing in mind the Ca-bearing nature of the particle, it could also be monticellite, a olivine with the formula Ca(Mg,Fe)[SiO_4]. Additionally, the weak nature of the signal compared to that of forsterite analogue impact samples shot into aerogel in the laboratory [5] are also consistent with the grain being metal-rich (since metals do not produce Raman signals) with less abundant silicate. Further work will include a carefully calibrated, high resolution scan to determine conclusively if the grain contains any monticellite – it having a similar spectrum to forsterite, but shifted downwards by only 5 cm^{-1} [6].

References

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