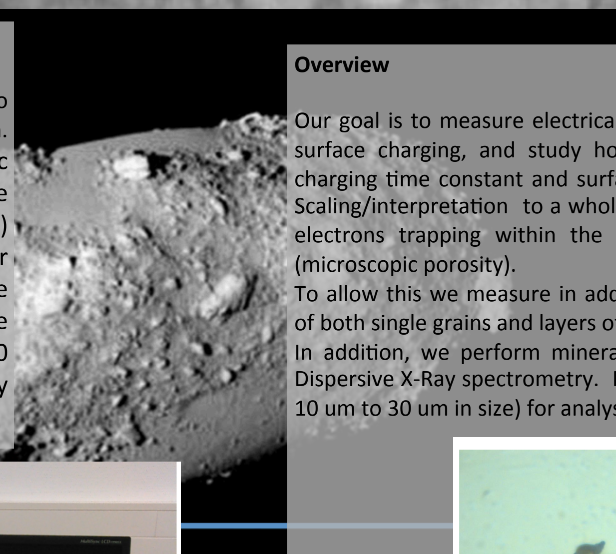
Itokawa grains – analyzing material returned by the Hayabusa mission

Cipriani, F., Koschny, D., Witasse, O., Colangeli, L.



Hayabusa

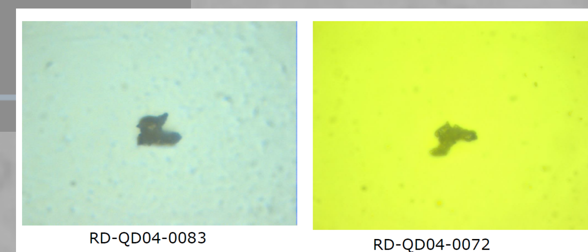
Hayabusa was a JAXA mission to asteroid (25143) Itokawa, launched in 2003. Two touchdowns occurred on 20 November and November 2005 in the MUSES-C region. In spite of a non-nominal deployment of the surface sampler, the elastic sampling horn impacting the surface directed surface dust into the sample catcher. The sample catcher containing a small sample of grains (~1500) from the surface of the asteroid was returned to Earth in June 2010. After some initial analysis, a call for science proposals went out to the science community in 2013. In a collaboration between D/SCI and D/TEC we have responded to the call and succeeded in getting three grains (between 10 and 30 um in size) for the analysis of their charging properties, morphology and mineralogical composition.

Overview

Our goal is to measure electrical properties, such as secondary emission yields and surface charging, and study how the grain morphology affects the electrostatic charging time constant and surface fields. We characterize single Itokawa samples. Scaling/interpretation to a whole regolith behavior is necessary but not easy due to electrons trapping within the layer in gaps between or within regolith grains (microscopic porosity).

To allow this we measure in addition the properties (charging, secondary emission) of both single grains and layers of JSC-1 simulant.

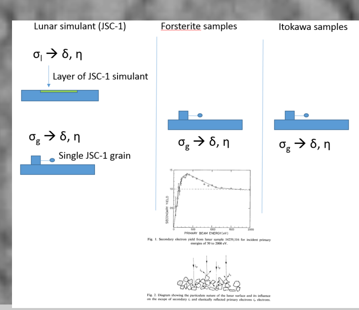
In addition, we perform mineralogical mapping using a micro-Raman and Energy Dispersive X-Ray spectrometry. In August 2014, we have received three grains (from 10 um to 30 um in size) for analysis.

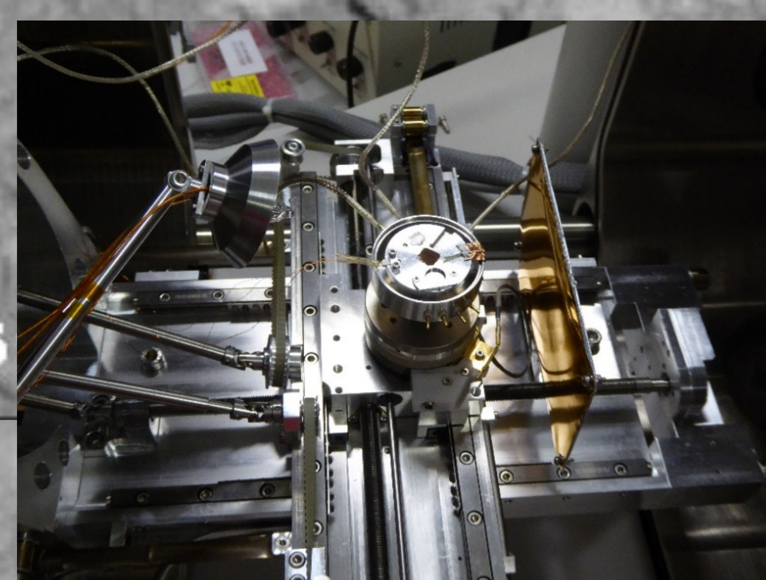


Two of the samples, sizes about 10 to 30 μm

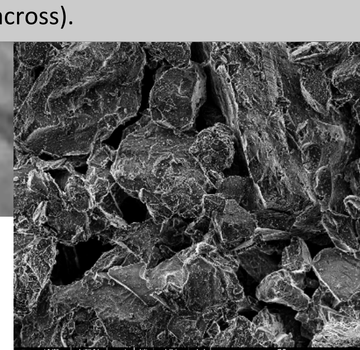
After establishing the method to measure grains surface electric field and electrostatic potential under low electron irradiation, a lot of work has been done to update and refine our handling capabilities for fine particles, as well as establishing a secure sample handling procedure using test particles. We have performed the first measurements on the real particle in 2016. This year a lot of effort was spent in consolidating the secondary emission measurement technique and in particular the measurement electronic which needs to be done in pulsed mode to avoid strong influence of the dielectric sample surface potential build up on the measured yields.

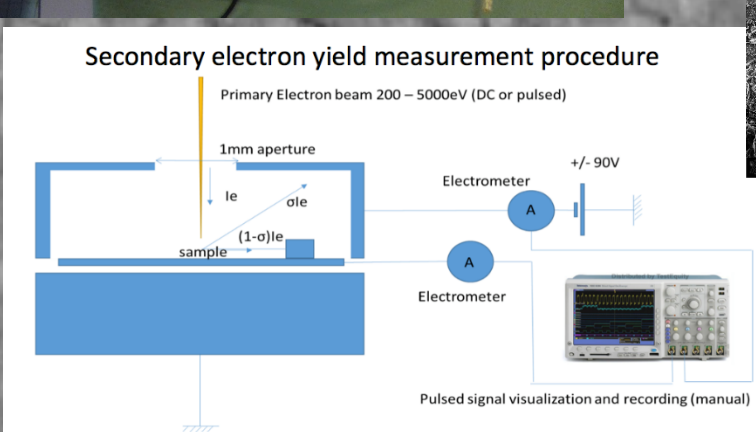
Console for operating the Scanning Electron Microscope (SEM).



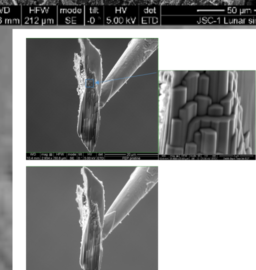


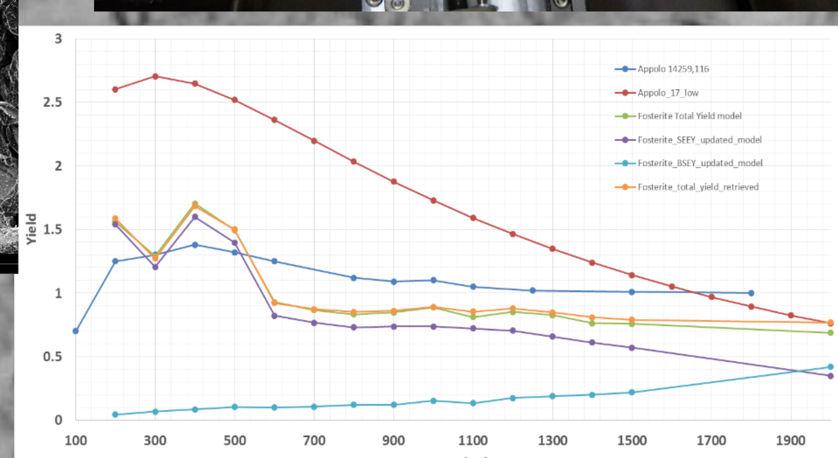
Left: JSC-1 layer deposited in sample holder to simulate regolith irradiation (low energy electrons: 200 eV until 5000 eV). Right: Installation in SEM. Bottom: SEM image of JSC-1 (50 μm across).





Ie = primary electron current
σ = fraction of primary current emitted back and collected by collector electrode biased at +/- 90 V with respect to sample
(1- σ) = fraction of primary current collected by sample
δ = electron secondary emission yield (= Isec / Ie)
η = electron backscattered yield (= Iback / Ie)





Measurement results with terrestrial Forsterite grain

Secondary emission yield (green curve);
Backscattered yield (light blue) derived from our model;
compared with Apollo 17 (red, single grain) and Apollo 14 (blue, regolith layer).
The total yield (orange) is close to the yield measured on Apollo 14 sample, incomplete water outgassing from our sample is presumably the main cause in this case. Ask Detlef for an explanation.

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Acknowledgements

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Background image credit: JAXA