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High velocity Van de Graaff shots of mineral dust: application to STARDUST and other in situ space missions

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The detection and collection of high velocity interplanetary or interstellar dust grains by space missions is a nontrivial task, as high speed impacts on collectors or detectors may cause significant structural and chemical modification. Hence, simulation of high speed dust impacts is required, e.g. into STARDUST aerogel or foils [1], or impact ionisation time-of-flight mass spectrometers as onboard CASSINI [2,3].

Particle speeds up to 50 km/sec can only be achieved by a Van de Graaff accelerator as operated at the Max-Planck-Institut für Kernphysik (Heidelberg). Here, only charged particles can be ac-celerated: While metals (e.g., Fe, Al) or magnetite work well, ac-celeration of silicates or organics requires a complex chemical coating procedure, to achieve acceptable levels of conductivity. A thin platinum coating [4] was successfully applied to analogue ma-terial like silicates (quartz, orthopyroxene, anorthite, olivine), and carbon rich particles (silicon carbide). Organic and sulfide (e.g. pyrrhotite) grains have been coated with a thin conductive layer of Polypyrrole [5], which allows acceleration in the Van de Graaff. All coated grains were successfully accelerated and provided im-pacts with speeds between 1 - 40 km/s.

Impact signals as well as high resolution impact ionisation mass spectra were evaluated using the large area mass analyzer [6] (LAMA). These TOF spectra provide a mass resolution of about 200 and allow for qualitative determination of mineral compounds and isotopes in individual grains. However, while for these kinds of experiments active selection of suitable particle impacts is possible, the preparation for shots into STARDUST collectors requires com-plete control of particle size and speed by an improved new version of specific Particle Selection Unit, which is currently implemented. This provides a clear advantage over shots with a light gas gun where single shots of selected grain within a narrow mass and speed range are not achievable.

Preliminary shots into Stardust flight spare tiles have been ex-tracted in picokeystones [7], and analyzed by Scanning Transmis-sion X-ray Microscopy at the Advanced Light Source at Lawrence Berkeley Laboratory[8] with ∼30nm spatial resolution. Quantiative measurements of the alteration of othopyroxene grains in residues of individual ∼1 pg impactors have been obtained, demonstrating the suitability of this method of sample preparation and analysis for fu-ture dust samples returned by the STARDUST mission.

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