National Aeronautics and Space Administration

FY23 Innovative Spontaneous Concepts Research and Technology Development (ISC)

Low velocity impact particles collector

Principal Investigator: Mircea Badescu (355)**; Co-Investigators:** Jessica Weber (322), Douglas Hofmann (357), Mathieu Choukroun (322)

Objectives:

1. Design an apparatus that accelerates particles with diameters of 10-20 microns (observational constraint) and density of 0.5 - 1g/cc to 1-10 m/s to impact a target.
2. Determine the sample collection and retention on various Au and Al substrate flat plates.

Background:

A JPL team is considering proposing a sample return mission to a set of active asteroids, sometimes called main belt comets (MBC), that show repeated cometary activity near their perihelia. One of the possible mission configurations is a rendezvous mission where the spacecraft collects dust particles ejected from the comet from an altitude of a few 10s km and at relative speeds of 1-10m/s. After collection, the sample is packed and stowed into a sample return capsule for return to earth. Currently JPL does not have a proven sample collection system that can capture dust at low speed. We have established that collection plates with a soft substrate would be adequate, however we lack insights into the collection efficiency of relevant materials for the mixture of organics and silicates expected at MBCs. This is a major uncertainty that drives the collection time requirements with implications for the overall mission.

Significance/Benefits to JPL and NASA:

We were able to determine that particles of the size expected to be encountered in a rendezvous mission to a main belt comet with sizes of up to 10 microns and speeds up to 10 m/s can be collected and retained on targets made out of annealed Al and Au plate and shim. The collected particles remained on the targets after exposure to 1g acceleration. Multiple particle layers were collected and most remained on the target even after tapping the target on a wood bench and so we conclude that mechanical manipulation of the targets after sample collection in a mission will not lead to significant collected sample loss.

The retained particles did not imbed into the targets thicker than 25 µm but dented or imbedded the submicron thick targets.

Having established that target materials that permit mechanical manipulation and cleaning can be used for collecting low velocity particles will allow JPL and NASA to propose rendezvous sample return missions to comets and asteroids.

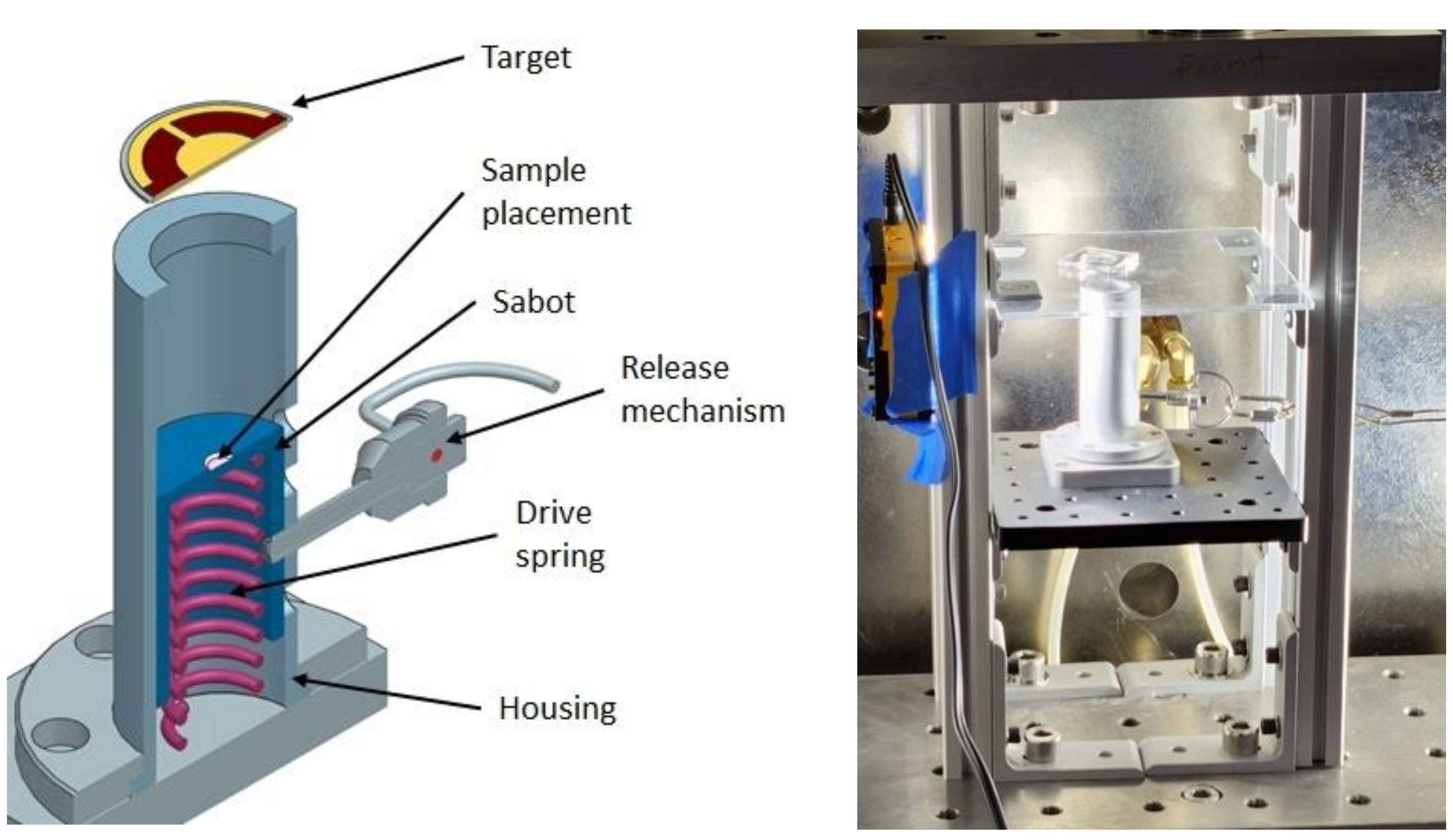


Figure 1. Particles acceleration apparatus design (left) and testbed (right).

Approach and Results:

We designed and built a spring driven captive sabot/piston particles acceleration testbed able to operate in vacuum and accelerate particles to 1-10m/s speeds onto a target to collect the particles. The apparatus was mounted on a frame inside a vacuum chamber that allowed for the releasing of the preloaded drive spring by pulling a quick release pin. Particles velocities were verified using high-speed video recordings.

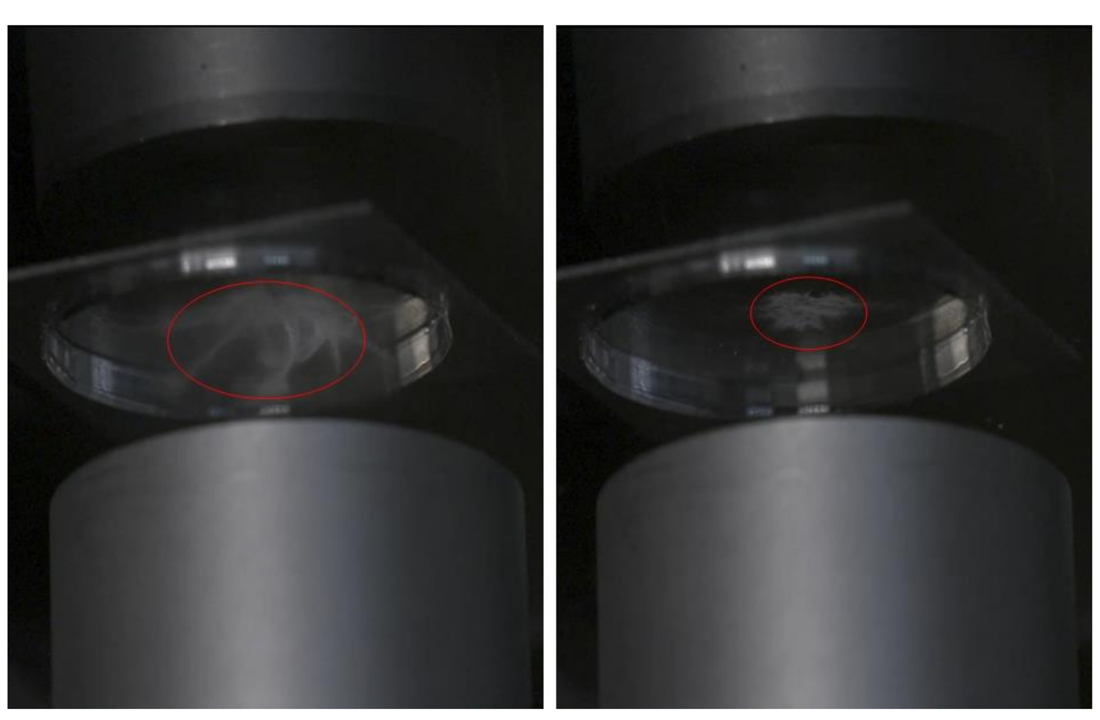
Two different sets of samples were used for testing: silica beads (10 micron and 60-200 mesh) and Manufactured Porous Ambient Comet Simulants (MPACS) ground and sieved to under 60 micron size.

The targets consisted of 25mm square coupons of annealed Al, 0.5 mm thick plate, and 25 µm and 50 µm thick shims; 25 µm and 50 µm thick Gold shims and 0.5 µm thick Gold and Silver leaf. The target was placed above the accelerating apparatus and the particles were shot upward. The particles that remained on the target were retained on the target against gravity. The test results were imaged using phone cameras and microscope. The sample was collected on the target for all Al and Au coupons for both plate and shims.

All Al and Au targets retained sample. Microscope imaging showed that multiple layers of sample were retained on the targets. Particles remained on the target even after a few days of exposure to 1g and after tapping the target on a wood workbench.

Cleaning the target after imaging showed that the particles impacts up to 10 m/s did not leave any indentation in the Al and Au plate and shim targets but they left indentations or were imbedded into the Au leaf targets. An efficiency of particles collection and retention process for each test was not calculated as the mass of the sample that impacted the target could not be determined.

Figure 2. 10-20 microns silica beads shot at the Al plate target at 10m/s during impact (left image) and what remained on the target (right image). High speed video recording screen shots, courtesy of JPL Photolab



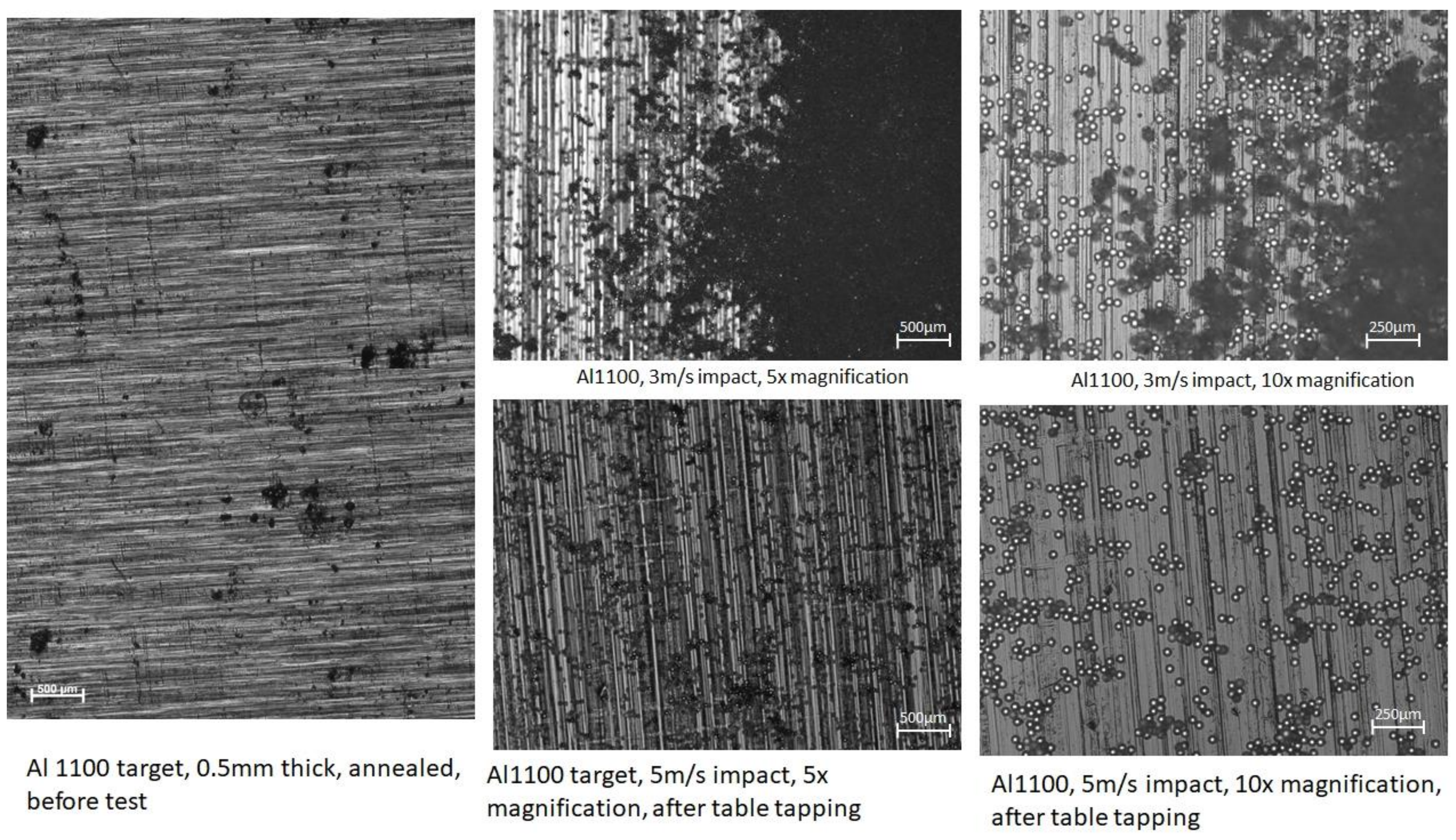


Figure 3. 10-20 microns silica beads shot at the Al plate target and retained after the impact.

PI/Task Mgr. Contact Information: Mircea Badescu, 818-393-5700; Mircea.Badescu@jpl.nasa.gov

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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