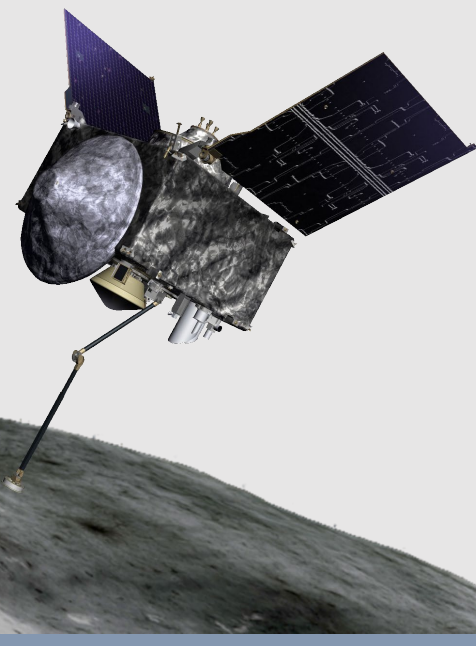


# Ultramicrotomy Sample Preparation of Bennu Particles at NASA Johnson Space Center

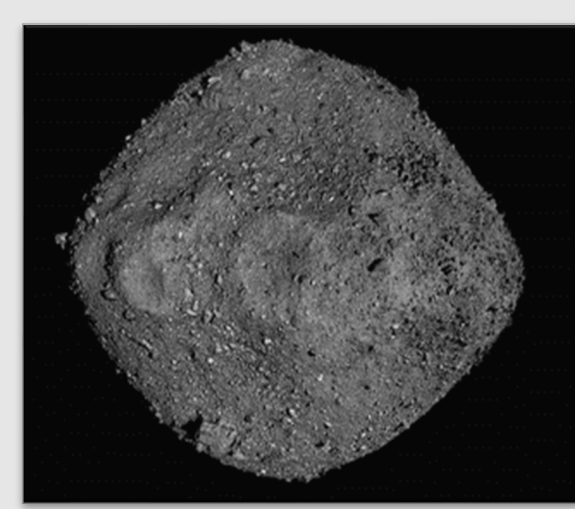
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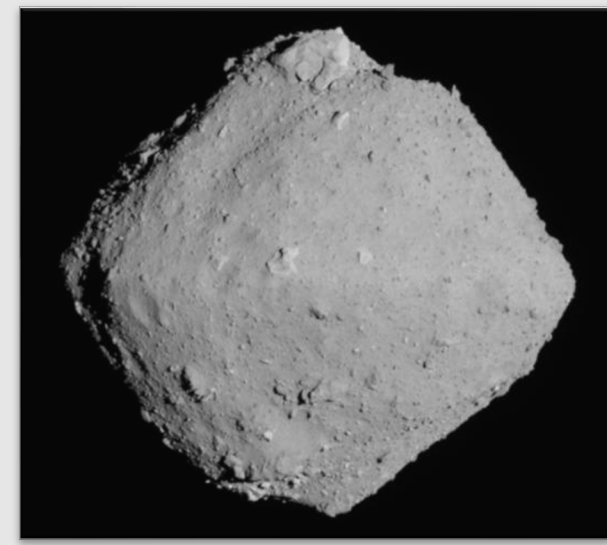


## Introduction

OSIRIS-REx and Hayabusa2 are sample return missions that collected carbon-rich material from asteroid Bennu and Ryugu, both containing OH-bearing surface materials in the form of clays [1]. Roughly 70 percent of the OSIRIS-REx sample collection [2] and 10 percent of the JAXA Hayabusa2 sample collection that was shared with NASA [3] are stored separately in a new curation ISO 5 cleanroom laboratory at NASA Johnson Space Center (JSC). Located between the two lab suites is an ISO 7 carbonaceous asteroid ultramicrotomy sample preparation laboratory that has the capability to fulfil requests for ultramicrotomed sections of Bennu and Ryugu particles from the scientific community. Ultramicrotomy is a technique used to produce 70-100 nm thick cross sections of particulate materials. The resulting microtome sections are available for a wide array of analytical techniques including non-destructive spectroscopies (e.g., Fourier-transform infrared spectroscopy), transmission electron microscopy (TEM), and NanoSIMS isotopic analyses, often in a coordinated fashion.

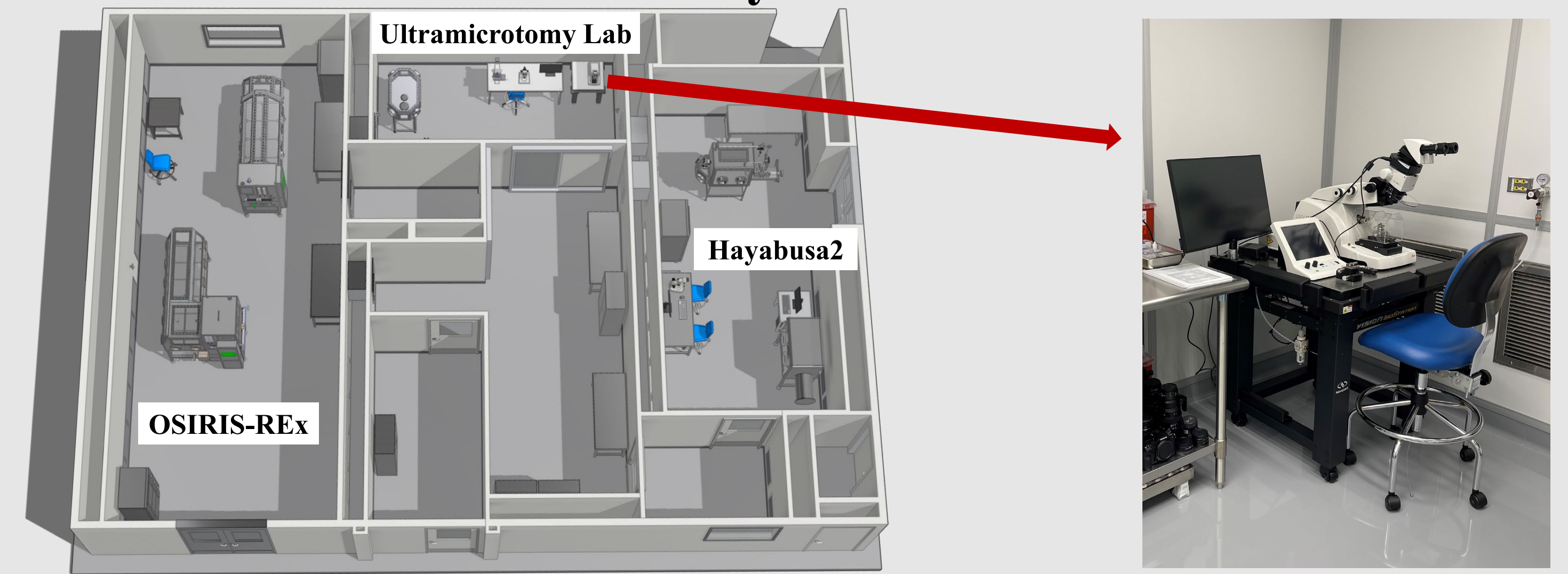


OSIRIS-REx: Asteroid Bennu [4]



Hayabusa2: Asteroid Ryugu [4]

## ISO 7 Carbonaceous Asteroid Ultramicrotomy Sample Preparation Laboratory at NASA JSC



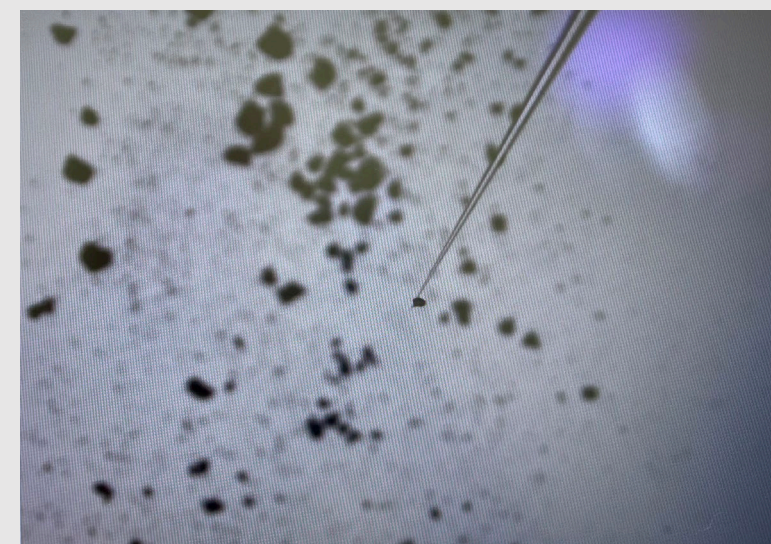
## Samples and Methods

For this study, we used ultramicrotomy to prepare particles from Bennu samples OREX-800068-0 and OREX-501018-0 for TEM analysis. This poster will discuss the JSC curation-related technique development used to achieve high quality sections.

## Sample Preparation

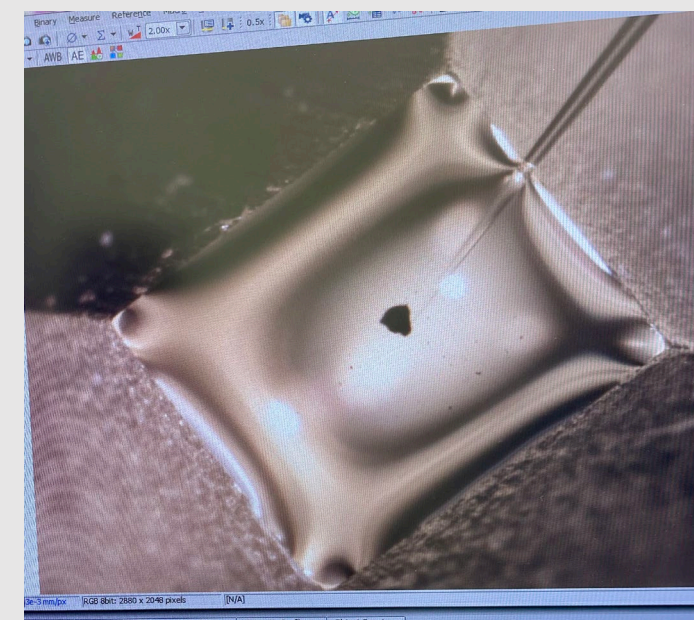
### Step 1: Particle Embedding

- Borosilicate glass needles were used to apply a small bead of embed 812 epoxy resin onto the face of the bullet and transfer a roughly 10-15  $\mu\text{m}$  sized particle into the bead of epoxy.



An  $\sim 15 \mu\text{m}$  sized particle from OREX-501018-0 adhering to the tip of a glass needle

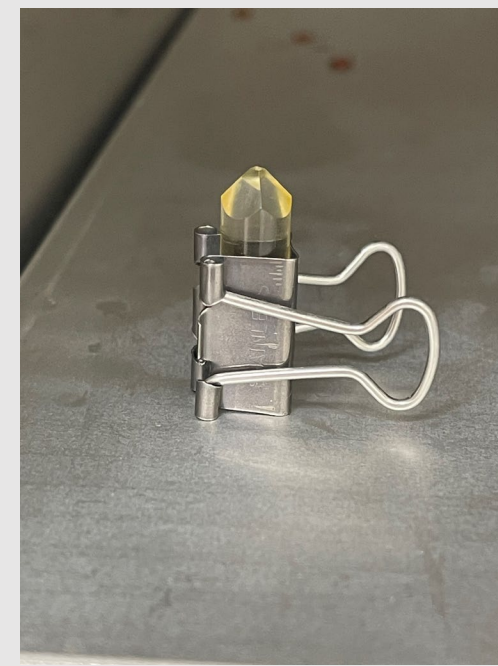
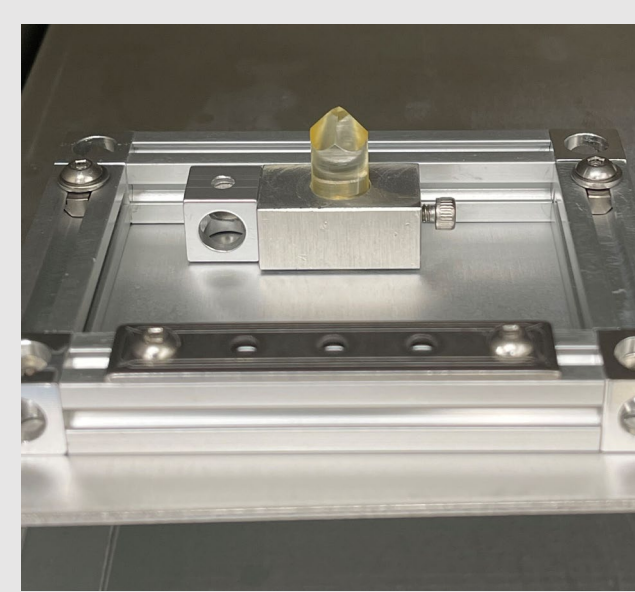
- Buoyancy would cause the particle to float to the surface and drift towards the edge of the bullet, suggesting a low particle density. A glass needle was used to gently manipulate the particle until it stabilized in the resin.



Glass needle used to manipulate a particle from OREX-501018-0

- The embedded particles were transferred to an apparatus to ensure a level surface and then cured in a 70°C oven for roughly 88 hours.

Custom made apparatus securing potted butt



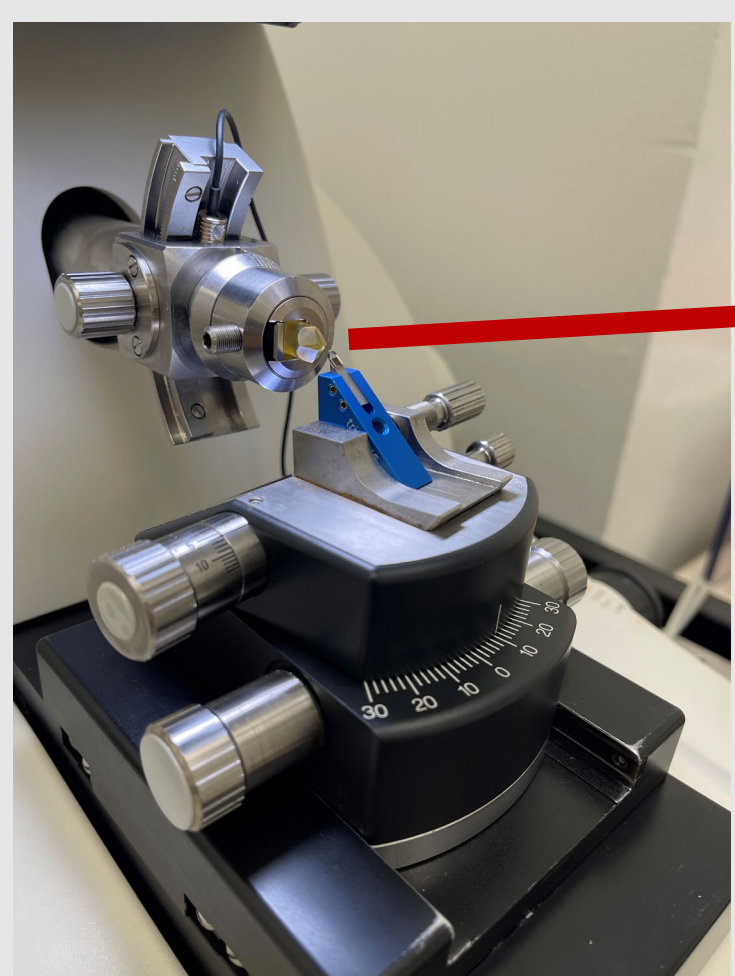
Stainless steel binder clip securing potted butt

### Step 2: Potted Butt Trimming

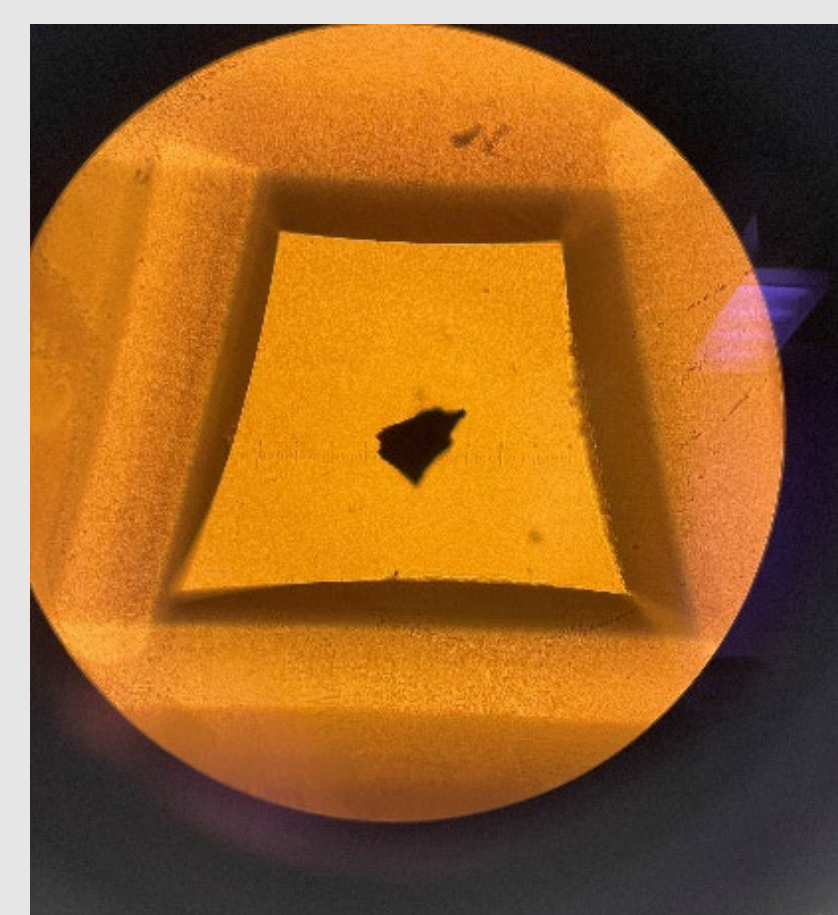
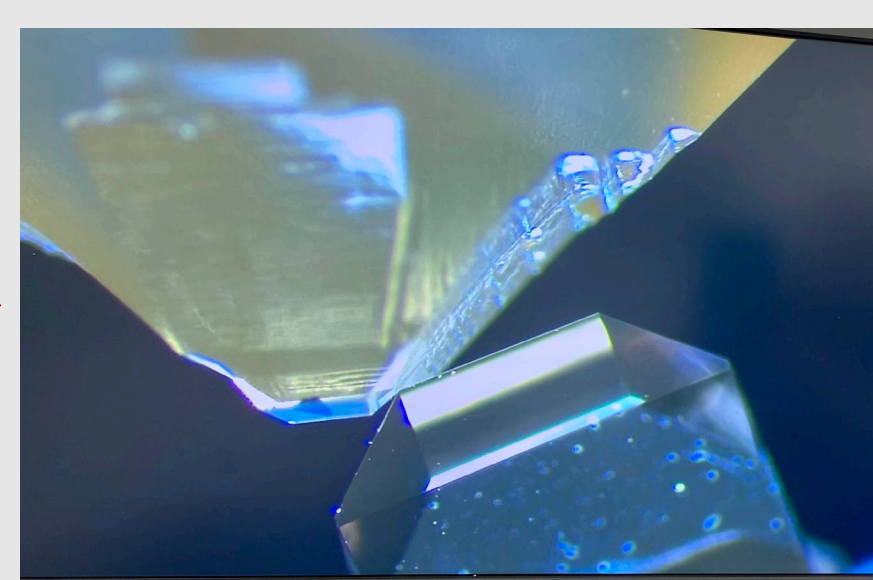
- A Leica EM UC6 ultramicrotome was used for trimming of the cured epoxy potted butts



- A diamond chisel with an incline angle of 45° was first used to trim the surface of the potted butt into a trapezoidal shape then, used to remove excess epoxy from the face of the trapezoid until the particle was about 2  $\mu\text{m}$  from the surface



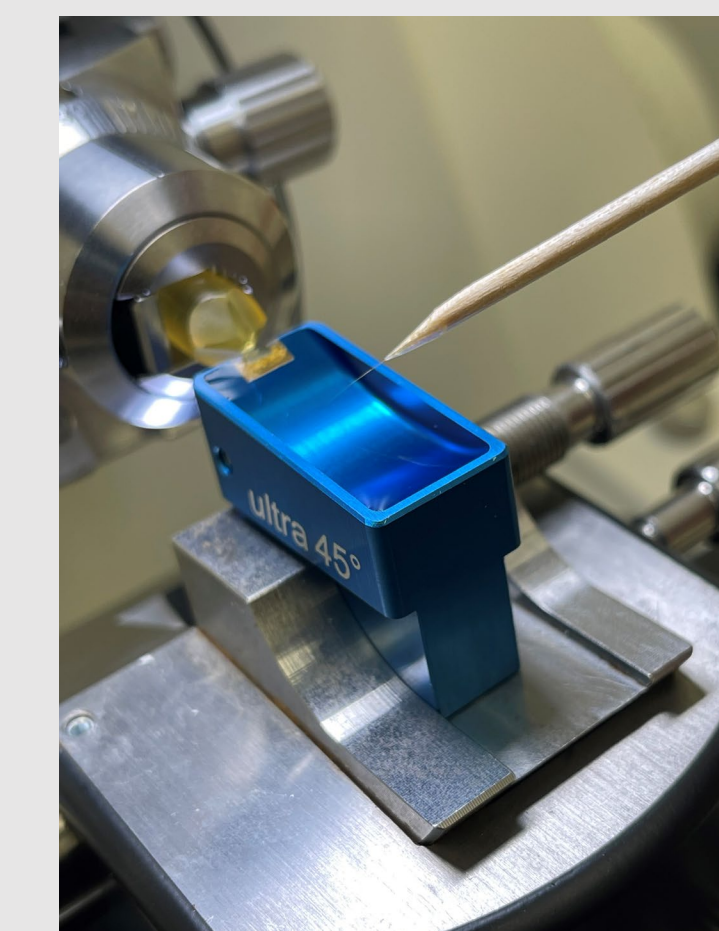
Trimming a potted butt of a particle from OREX-800068-0 into a trapezoidal shape



Trimmed potted butt of a particle from OREX-501018-0. Photo is taken through microscope eyepiece at 20X objective

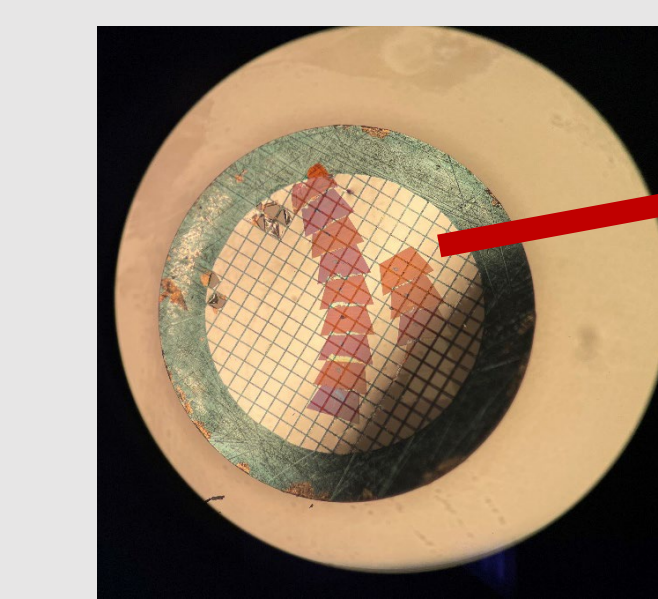
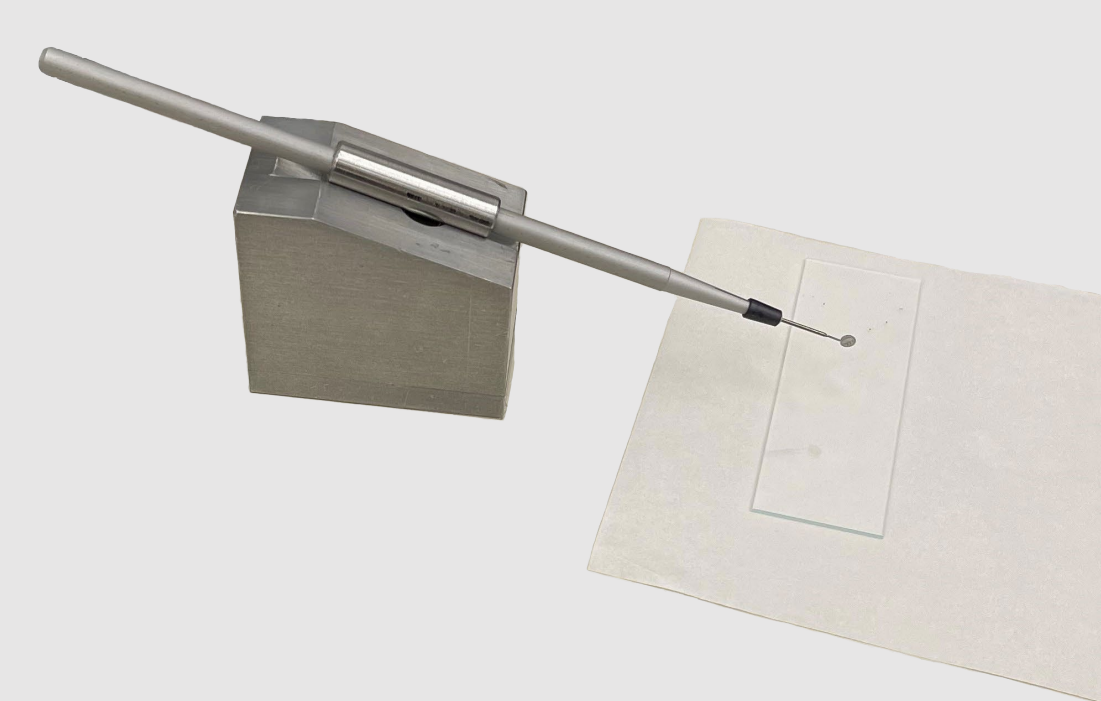
### Step 4: Transferring Sections Onto A TEM Grid

- After the first initial slices of the samples were taken, a single hair manipulation tool was used to detach the sections from the knife and separate the ribbon of particle cross-sections (pictured below)



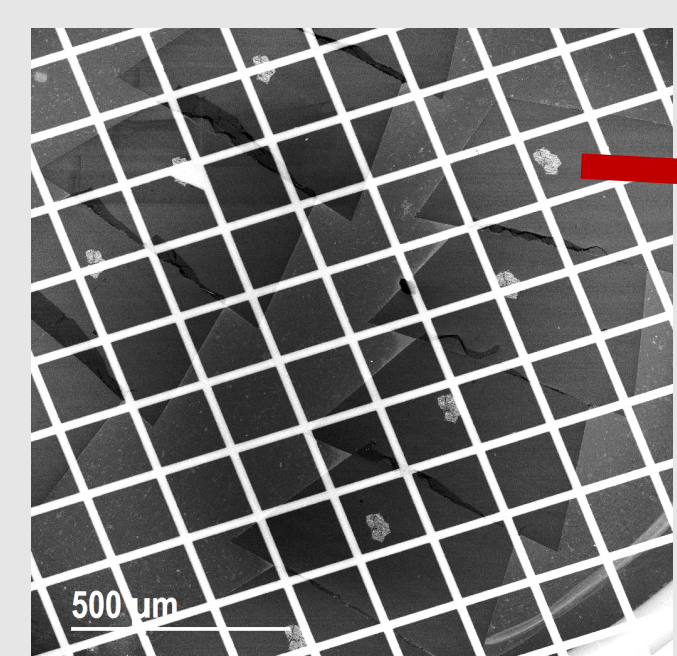
Perfect Loop tool resting on an apparatus to allow the TEM grid to dry and safely detach

- A Perfect Loop tool was used to carefully transfer the sections from the reservoir onto a carbon coated TEM grid for analysis

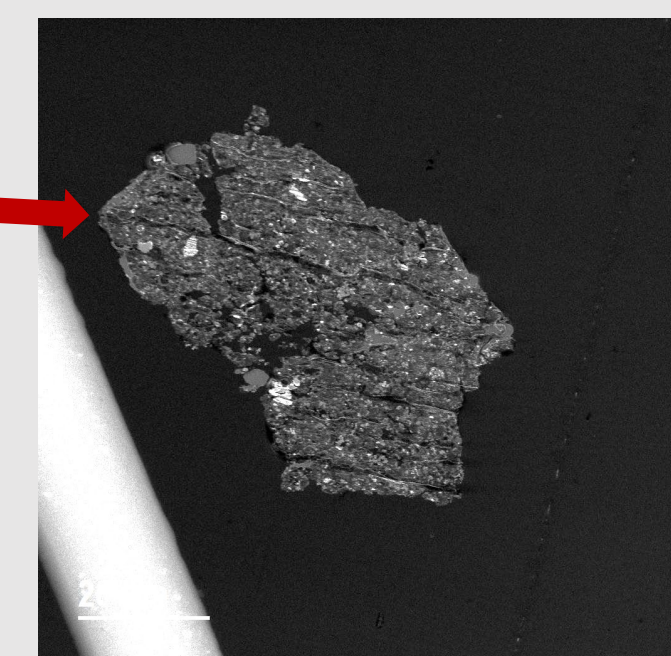


Carbon coated TEM grid with microtome sections from OREX-800068-0. Images taken through microscope eyepiece

### TEM Thin Sections of OREX-800068-0



Microtome thin sections on transmission electron microscope grid - brightfield STEM (scanning, transmission electron microscope) images.



Largest microtome thin section ( $\sim 70 \text{ nm}$  thick) on transmission electron microscope grid - secondary electron image.

### SCAN THE QR CODES TO VIEW AND REQUEST OSIRIS-REx SAMPLES!

Sample and Photo Catalog



Advanced Imaging & Visualization of Astromaterials



References: [1] Laurretta, D. S. et al. (2024). *Meteoritics and Planetary Science*, DOI: 10.1111/maps.14227. [2] Wilcox, Kevin. (2023, October 30). *OSIRIS REx Sample Wows Scientists*. [3] Lindsey, Lauren. (2024, November 3). *Hayabusa2*. [4] Reid, N. (1975). *Ultramicrotomy (Practical Methods in Electron Microscopy Series, Vol 3, Pt 2)*, Elsevier Press, 353 pp. [4] Amanda Barnett, A. (2021, December 8). *In depth: Hayabusa2*. NASA.