USING FOCUSED ION BEAM MILLING TO MODIFY CONDUCTIVE AND CHARGE-DISSIPATIVE SUBSTRATES FOR MICROPARTICLE STORAGE AND CHARACTERIZATION.

C. J. Snead[1,2], Z. Rahman[1], F. M. McCubbin[3] [1]JETS, NASA Johnson Space Center, Houston TX 77058, USA. (christopher.j.snead@nasa.gov) [2]Texas State University, San Marcos, 601 University Dr., San Marcos, TX 78666, USA [3] NASA Johnson Space Center, Mailcode XI2, 2101 NASA Parkway, Houston, TX 77058, USA.

Introduction: The Astromaterials Acquisition and Curation Office at NASA Johnson Space Center is currently developing tools and methods that will enable the curation of future astromaterials collections [1]. One particular objective of the advanced curation program is the development of new methods for the collection, storage, handling and characterization of small (<100µm) particles or microparticles. At these scales, triboelectric effects [2] can cause microparticles, manipulation tools, and storage substrates to acquire excess charge; electrostatic repulsion due to this charging is the primary mechanism by which particles are lost during transfer operations. The effects of triboelectric charging have typically been mitigated by the use of Po-210 ionizers, and by operating in atmospheric conditions with a relative humidity >40% [3]. However, Hayabusa2 and OSIRIS-REx mission requirements necessitate the curation of samples in dry N_2 processing cabinets [2,3]; in these low-humidity environments, Po-210 ionizing sources may be insufficient in suppressing triboelectric charge accumulation. As part of our Advanced Curation research, we have investigated the use of charge-dissipating substrates as a means of mitigating triboelectric effects.

Charge-Dissipative Substrates: Microparticles removed from cosmic dust collectors have traditionally been stored and distributed to investigators in glass concavity slides; we have identified friction between these slides and particles as a major source of sample electrification. In cases where substrate transparency is not a curation requirement, the glass slide may be replaced with a conductive or charge-dissipative substrate such as silicon. Particles retain a high level of visibility on such substrates, and triboelectric charging is significantly reduced such that microparticles can be reliably manipulated in ambient atmospheric conditions without the use of a Po-210 source. Recently, we have experimented with producing storage receptacles in silicon using focused ion beam (FIB) milling.

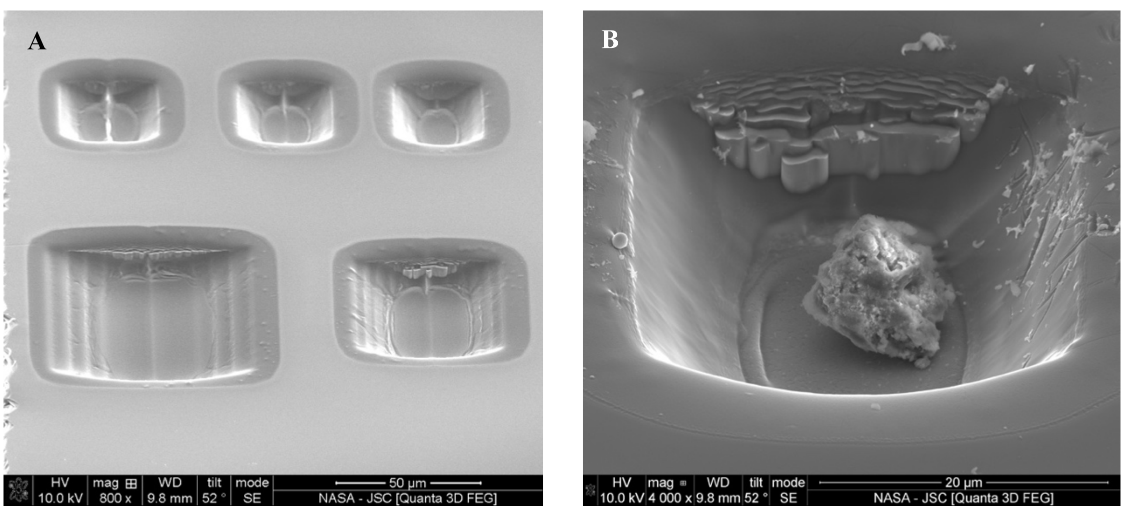

Figure 1: A) Particle wells produced via FIB milling. B) Secondary electron image of 10µm particle in well.

FIB-Produced Particle Receptacles: We used an FEI Quanta 3D-FEG Focused Ion Beam (FIB) to mill several shallow (<20µm) depressions between 30µm^2 and 80µm^2 into the surface of a silicon chip; material was sputtered using a 65nA Ga^+ beam at 30kV. A 10µm particle of CM2 meteorite was placed into one of the FIB-produced wells using a pantograph mechanical micromanipulator. The charge-dissipative nature of the Si chip enabled us to successfully acquire a secondary electron image of the stored particle using a 190pA beam current at 10kV. Storage substrates that also enable electron beam imaging and characterization are desirable, as they minimize the need for high-risk microparticle transfers between storage and analysis substrates. We are currently investigating this technique to produce storage wells in other charge-dissipative substrates that could enable in-situ elemental analyses.

References: [1] McCubbin F. M. and Zeigler R. A. (2017) *Hayabusa 2017 Symposium of the Solar System Materials*. [2] Matsusaka S. et al. (2010) *Chemical Engineering Sci., 65*, 5871-5807. [3] Guardiola J. et al. (1996) *Journal of Electrostatics, 37*, 1-20. [4] Minamino H. et al. (2012) *Asteroids, Comets, Meteors,* Abstract #6188. [5] Lauretta D. S. (2017) *Space Science Reviews 212,* 925-984.