**Ultrapure Water System at JSC for High Purity Cleaning of Flight Hardware, Astromaterial Handling Tools and Solar Wind Samples.** J. H. Allton[1], K. K. Allums[2], R. Bastien[2], M. J. Calaway[2], D. B. Carrejo[1], C. P. Gonzalez[2], and S. A. Leal[2]. J. McQuillan[2], [1]NASA/Johnson Space Center, Mail Code XI2, 2101 NASA Parkway, Houston TX 77058. Judith.H.Allton@nasa.gov. [2]Jacobs – JETSII at NASA Johnson Space Center, Houston, TX.

**History:** Use of Ultrapure Water (UPW) for cleaning of astromaterial sample handling tools and containers was driven by the discontinuation of Freon 113 as a cleaning solvent, due to environmental concerns. Freon 113, recycled using distillation, was very effective at removing organic residues from sample handling hardware. The initial switch to high purity water for astromaterial tool cleaning was modeled after efforts at White Sands Test Facility (WSTF) and current semiconductor UPW production practices in the early 1990s. JSC curation's first system was comprised of ion exchange polishing cylinders, 55 gallon PVDF-lined storage tank, a few tens of feet of PVDF piping, UV and particle filtration [1,2], and this system supported cleaning for lunar, meteorite and Cosmic Dust collectors lab operations. By 2000 a major expansion and upgrade was providing UPW of quality E-1 (ASTM D5127-90) or better at 10 gpm for cleaning of the Genesis solar wind payload for flight, in addition to sample handling tools for other astromaterials [3]. This expansion included a 1000 gallon storage tank and several hundred feet of PVDF piping located in B. 31 and 31N. An extra reverse osmosis process unit was added to incoming water in 2005. Subsequently several major components were replaced, and in anticipation of adding new labs, an enlarged UPW system was designed in 2018 and completed in 2019. This system produces grade E1.1 UPW at 15 gpm in a continuous 1100 ft. loop with 5000 gal. storage tank, supplying 8 laboratories.

**Components of UPW system:** UPW, with metal cation and anion concentrations in the low parts per trillion, is prepared by continuous filtration (at 0.04 µm particle size), irradiation with 254 nm UV and 185 nm UV, and ion exchange (Fig. 1). The result for curatorial UPW quality is resistivity of 18 MΩ $cm^{-1}$ and a total oxidizable carbon (TOC) concentration of typically <2 ppb. Water this pure is a reactive solvent. It reacts with containers; thus, it is produced and used dynamically. Cleaning is done with flowing UPW, either in an ultrasonic cascade tank or megasonic wand for large items or in-place cleaning of gloveboxes (Fig. 2). The resulting particle cleanliness level for large items is typically < level 50, based on rinse water particle count. Calaway *et al.* [4] present a controlled test of curation glovebox cleaning with rinse water particle size distributions and composition distributions.

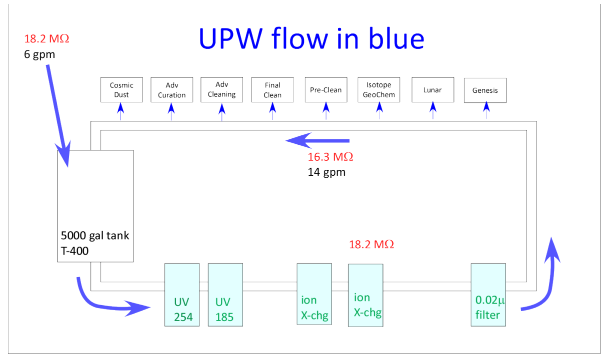


Fig. 1.

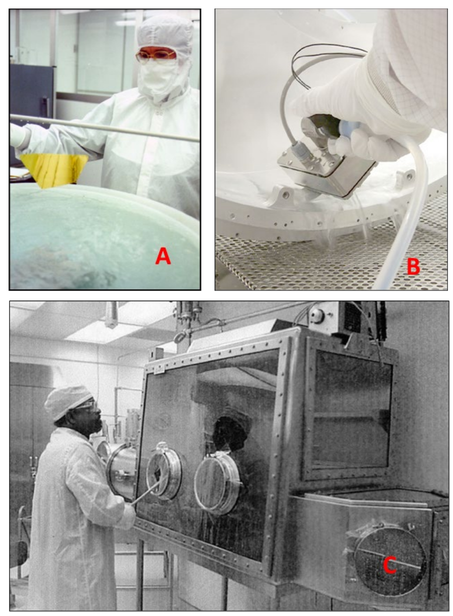


Fig. 2. A, cascade tank, B megasonic wand. C glovebox.spray.

**UPW cleaning Genesis payload for flight:** UPW was used for cleaning the Genesis payload for flight because, as a high purity solvent, it left little residue for this very contamination-sensitive mission. We were able to observe effects of UPW on the hardware surface. Most flight hardware is made with aluminum 6061 with clear anodize, Type II, Class 1 finish (MIL-A-8625). Since the anodize process adds contamination, it was decided to fabricate Genesis structural components without an anodize finish from aluminum 6061 and 7075. We observed oxides on both 6061 and 7075 which could be reduced using lower temperatures and cleaning times (Fig. 3).

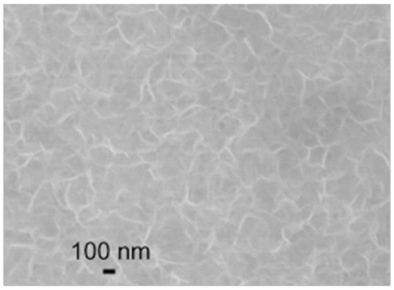


Fig. 3a. The wrinkled texture of hydroxides (boehmite?) resulted from cleaning of 6061 at 75C for 30 min.

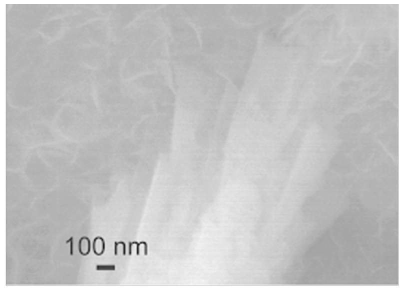


Fig. 3b. Needle laths (bayerite?) 6061 at 75C for 30 min.

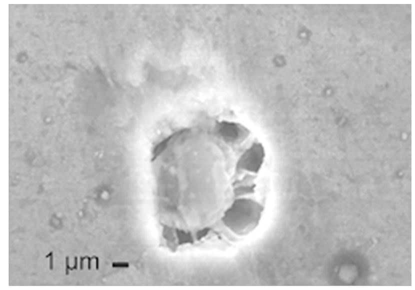


Fig. 3c. Erosion pit around inclusion in 6061, 50C for 30 min.

**UPW cleaning of Genesis samples to remove contamination:** The highly polished Genesis solar wind collectors offered ways to optically directly observe and quantify removal of particles from a variety of materials, unlike secondary assessments made from rinse water analysis.

*Spin cleaning collector fragments*. M. J. Calaway melded the megasonically energized UPW with a wafer spinner (semi-conductor tool) to provide a unique cleaning method for Genesis collector fragments [5]. The megasonic head sprays UPW on the collector surface while the fragment is spinning at 3000 rpm removing particles along with the UPW. It is like taking a shower compared to sitting in a bathtub (Fig. 4).

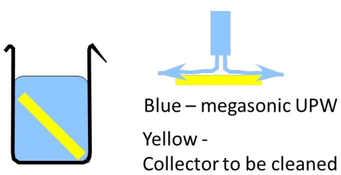


Fig. 4. UPW spin cleaner

Spin cleaner testing on Genesis silicon sample 60458 yielded results in Fig. 5 for particles counted in a 1 $mm^2$ image [5]. A brief cleaning time resulted in large reduction of particles.

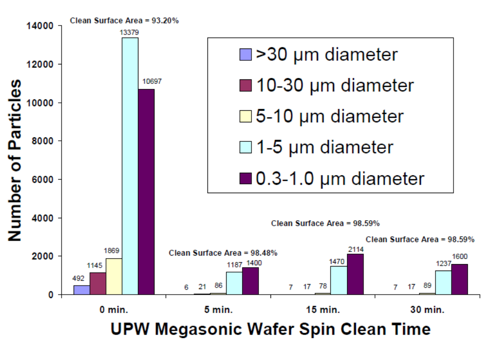


Fig. 5.

*Iterative UPW cleaning.* Due to the collaborative nature of cleaning experiments and/or sample sharing, UPW was sometimes used to remove contaminants added during cleaning or analysis by others (Fig. 6) [6].

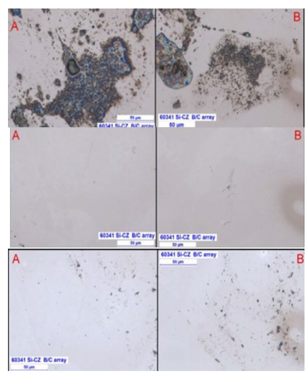

Fig. 6. Changes are documented in areas A and B silicon sample 60341 before and after UPW

After ion implant, TOF-sims

After UPW

After hot xylene .

**Summary of UPW use in sample curation:** UPW is a high purity, non-contaminating, aggressive solvent for cleaning flight hardware, astromaterial sample handling tools and containers, and solar wind samples. Highly polished solar wind collectors provide an observable direct measurement of particulate contamination.

**References:**

[1] Gooding, J.L. (1993) JSC Cur. Archives Pub. 120215. [2] Townsend, J.E. *et al* (1993) JSC Cur. Archives Pub.-9824. [3] Hango R. A. *et al* (2000) High Purity Water Used for Moon and Mars Specimen Curation. *Ultrapure Water 2000*, Philadelphia PA Apr. 11-13, 2000. [4] Calaway M. J. *et al.* (2014) NASA/TP-2014-217393. [5] Calaway M. J. et al.(2009) 40th LPSC, #1183. [6] Gonzalez C. P. et al. (2014) 45th LPSC,#2127.