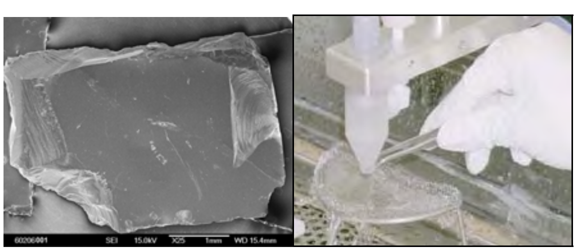
CLEANING GENESIS SOLAR WIND COLLECTORS WITH ULTRAPURE WATER: RESIDUAL CONTAMINANT PARTICLE ANALYSIS. J.H. Allton[1] , S.J. Wentworth[2], M.C. Rodriguez[3] , M.J. Calaway[2]: (1) NASA, Johnson Space Center, Houston, TX; (2) Jacobs at Johnson Space Center , Houston, TX; (3); Geocontrol Systems at Johnson Space Center, Houston, TX judith.h.allton@nasa.gov.

Introduction: Additional experience has been gained in removing contaminant particles from the surface of Genesis solar wind collectors fragments by using megasonically activated ultrapure water (UPW)[1]. The curatorial facility has cleaned six of the eight array collector material types to date: silicon (Si), sapphire (SAP), silicon-on-sapphire (SOS), diamond-like carbon-on-silicon (DOS), gold-on-sapphire (AuOS), and germanium (Ge). Here we make estimates of cleaning effectiveness using image analysis of particle size distributions and an SEM/EDS reconnaissance of particle chemistry on the surface of UPW-cleaned silicon fragments (Fig. 1). Other particle removal techniques are reported by [2] and initial assessment of molecular film removal is reported by [3].

Cleaning with ultrapure water: The typical properties of UPW used in JSC curatorial labs consist of 18 MΩ resistivity, ionic levels in the low ppt and TOC < 10 ppb. The water is energized via a megasonic (1 MHz, 0.4 A, 60 W) spray head and applied directly above the fragment to be cleaned at a distance of about 3-5 mm (Fig. 2) to remove particulate contaminants. UPW temperature is 40º C. Single crystal collector substrates withstand this cleaning process with no discernable damage under high magnification imaging. Coated substrates (sputter-deposited AuOS, DOS) are more fragile and the coating can be delaminated and removed by cleaning. An exception to this observation is seen in SOS, an epitaxially grown film which is durable under UPW cleaning. Typical cleaning times for Si and SAP 5 min., SOS 1 min., DOS and Ge 30 sec, and AuOS 10 sec.. Table 1 shows variable effects of 1 and 10 second cleaning for 6 AuOS fragments. Gold film loss is affected by extent of impact damage; however, brief exposure to UPW increases gold surface area by removing obscuring particles.



Figs. 1&2. SEM image of UPW-cleaned silicon (scale bar 1 mm). Placement of fragment to be cleaned under flowing, megasonically activated ultrapure water.

Table 1.

Sample	UPW Time (sec)	Gold Surface Area mm2	Sample	UPW Time (sec)	Gold Surface Area mm2
41283	0	73	60184	0	41
	1	79		1	46
	10	76		10	45
41284	0	36	60185	0	80
	1	38		1	83
	2	29		10	84
60182	0	42	60186	0	65
	1	46		1	69
	10	41		10	69

Post-cleaning particle size distribution analysis: Using images taken for sample documentation, we have applied ImagePro Plus software to recognize and tabulate particle size distributions. The results are not straightforward since no distinction can be easily made between a true particle and a gouge or scrape. However, comparison of the size distribution seen in 50X images of DOS sample 60244 and silicon sample 60178 hints that UPW cleaning removes most particles > 5 µm and some particles down to 0.4 µm size, but is not as effective below that about 0.4 µm (Fig.3).

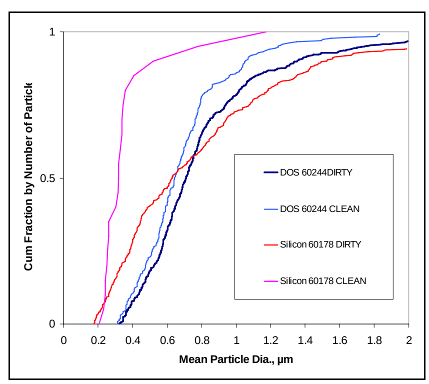


Fig. 3. Comparison of uncleaned vs cleaned surfaces of DOS sample 60244 and silicon sample 60178.

Post-cleaning particle composition analysis: Two 3-5 mm fragments of silicon were UPW-cleaned and examined via SEM/EDS to assess composition of particles remaining on the collector surface after cleaning. Sample 60205 was Pt coated, while sample 60206 was not coated. Most particles remaining on the surface are silicon, fragments of the collector material. Ridges on both samples are associated with gouges and chips in the collector surface. The silicon in ridges is partly fragmental and partly melted. Incipient low-velocity microcraters also seem to be present. Composition of particles is shown in Table 2. The likely source of aluminum oxide particles are the sapphire collectors and source of ZnGaAlO particles are spacecraft materials.

Table 2. Samples 60205, 60206: 1-5 µm particles. All dimensions in µm.

Particle type	L=1-5 W=1-5	L=1-5 W <1	L= 1-5 all
Si	37	31	68
Aluminum oxide	2	2	4
C-rich	3	1	4
ZnGaAlO	2	1	3
stainless	0	1	1
Total	44	36	80
L, mean	2.7	1.6	2.2
W, mean	1.6	0.7	1.2

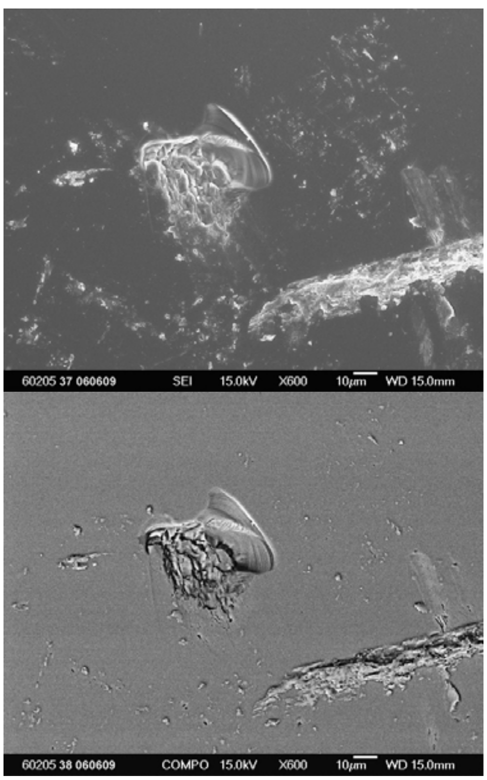


Fig. 4: 60205 surface in SEM and BSE modes; chips and abrasions with associated ridges (lower right) are common; micron-scale particles are abundant; Si is the predominant particle type, and materials other than Si are found only rarely in scrapes and ridges; smallest bright particles in BSE image are Zn/Cu. Scale bar is 10 µm.

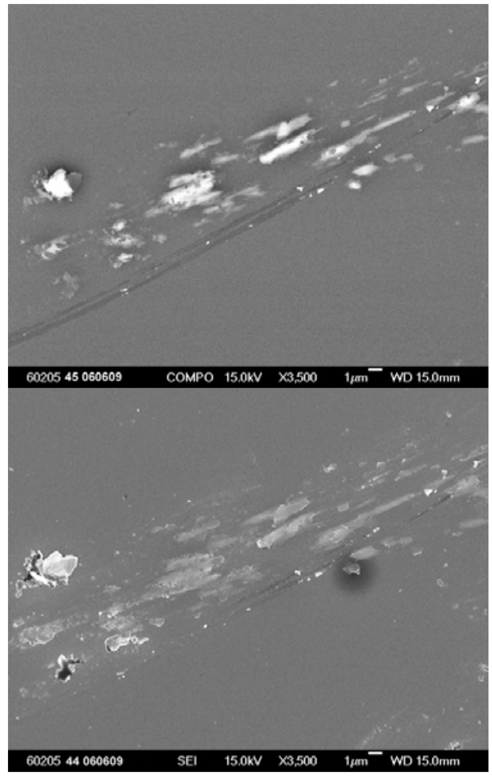


Fig. 5: 60205 smeared and embedded stainless steel (bright, micron-scale grains and areas) on wafer fragment surface; brightest submicron fragments in BSE image (compo) are ZnCu. Scale bar is 1 µm.

Summary: UPW cleaning of array collector fragments removes most particles >5 µm and some particles >0.5 µm. Composition of remaining particles is primarily crushed collector material, not Utah or spacecraft component material.

References: [1] Allton J.H. *et al*. (2006), LPSC XXXVII, Abstract #2324. [2] Kuhlman K. & Burnett D. S (2007) LPSC XXXVIII. [3] Calaway *et al*. (2007), LPSC XXXVIII, Abstract #1627.