

Abstract:

Inter-cavity copper plated bellows are part of the LCLS-II cryomodule beamline components. Since the bellows are close to SRF cavities during accelerator operation, it is desirable that these bellows have similar cleanliness as SRF cavities. Studies have been done to evaluate bellows cleanliness after the standard high vacuum parts cleaning procedure at Jefferson Lab. Additional cleaning methods are being explored to improve bellows cleaning process.

Background:

- Bellows are cleaned using standard hardware cleaning process except that lower solution temperature and expedited drying are applied.
- The convoluted shape presents challenge for cleaning and drying.
- The adhesion quality of the plating adds concerns during processing.



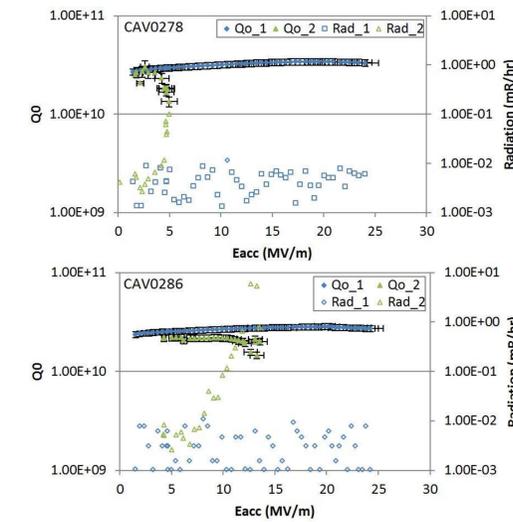
Experiments:

- Processing of cavities and bellows:
 - 3 field emission (FE) free cavities and 3 bellows received standard cleaning for string preparation;
 - CAV0116-Bellows2106 final connection made horizontally;
 - CAV0278-Bellows2068, CAV0286-Bellows2113 received HPR with bellows on the top during rinsing.
- Vertical RF testing:
- Particle sampling:
 - Interior of CAV0278-Bellows2068 were sampled in the cleanroom by two methods, L series (L1-L6) and S series (S0456-S0463).
- Analysis:
 - Particle topography, composition, and size were measured using SEM/EDS

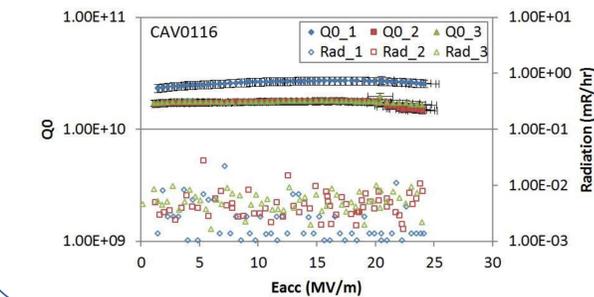


Vertical testing results:

CAV0278-Bellows2068, CAV0286-Bellows2113 received HPR with bellows on top before final assembly. Both previous FE-free cavities showed early FE onset (Series 2 on plots).

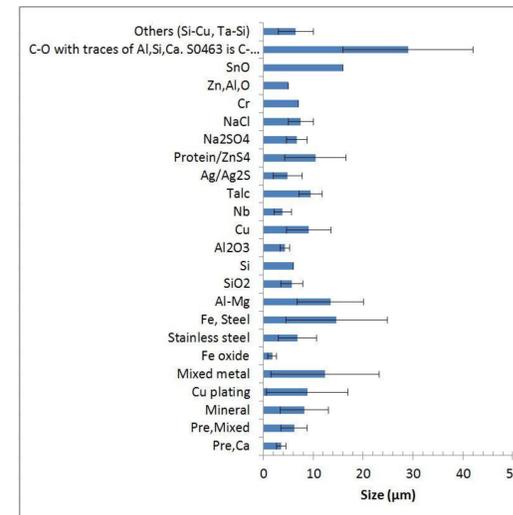
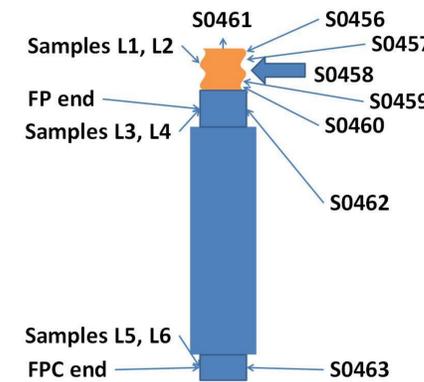


CAV0116-Bellows2106 sub-assembly was done using string assembly routine: bellows and cavity were cleaned separately; final connection was made horizontally. No FE observed before (Series 1) and after (Series 2) bellows attachment, even after bellows were flexed in-situ (Series 3).

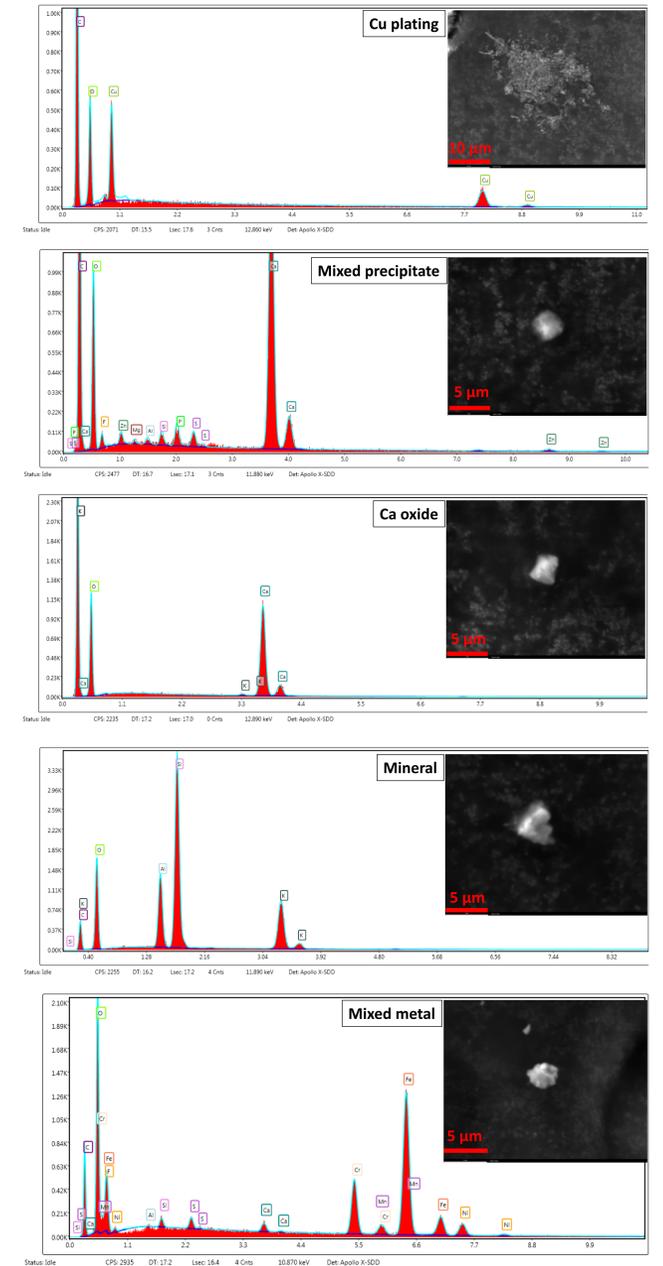


Particle sampling/analysis of CAV0278-Bellows2068:

- Total of 219 particles analyzed. Divided into 24 categories based on topography and composition. Particle size of each category summarized.
- Copper plating, mineral, and precipitation (Ca or mixed) appeared in both L series and S series. They are likely the source of field emitters.



SampleID	Total # of	Pre,Ca	Pre,Mixed	Mineral	Cu plating	Mixed met	Fe oxide	Stainless t	Fe, Steel	Al-Mg	SiO2	Si	Al2O3	Cu	Nb	Talc	Ag/Ag2S	Protein/Zn	Na2SO4	NaCl	Cr	Zn,Al,O	SnO	C-O with t	Others (Ta)
L1	2	1																						1	
L2	7	1	1	1	2			1		1															
L3	13			1	4			3																	
L4	20	5		3				2	2			1		1											2
L5	12	4	3	1				1						1											
L6	12		1	5				1	2	1													1		
S0456	17		2	3	2	2											6			2					
S0457	12	1	4	2	1			1	1			1							1						
S0458	18		4	3	7	1					1								1						1
S0459	20	2	1	1	4	5				1	3	1										1			
S0460	29		7	2	5	3						2			5					1	2				1
S0461	16	6	2							1				1			2	3						1	
S0462	19		4	3	5					1	1						3	1							1
S0463	22	1	3	1	1			1	1				1		9			2							2



Conclusion:

- Current bellows cleaning and assembly technique provides satisfactory cavity performance.
- HPR of copper plated bellows are likely to disturb particles or plating on the surface and cause unwanted particle migration.
- A process is established to sample and analyze particulates.