VACUUM EVACUATION EFFECT ON ICHIRO 9CELL CAVITIES DURING VERTICAL TEST

F. Furuta#, K. Saito, T. Konomi
KEK, High Energy Accelerator Research Organization, 1-1 Oho, Tsukuba 305-0801, Japan

Abstract

We have continued high gradient R&D of ICHIRO 9-cell cavities at KEK. The maximum gradient of ICHIRO 9-cell cavity #5 that has no end group on beam tubes was still limited around 36MV/m so far. The 9-cell performances were sometimes limited by triggered field emission (FE) by multipactings. We suspected the residual gas in the cavity might be one of the sources of triggered FE. The cavity was closed during vertical test in our system. Other labs evacuates cavity during vertical test. In order to improve the vacuum of cavity during vertical test, we made evacuation system in our cavity test stand. The comparison of results for vertical test with and without evacuation will be reported.

INTRODUCTION

We have demonstrated the principle proof of 50MV/m with ICHIRO single cell cavities [1]. The both centre and end cell shapes of ICHIRO have no problem on RF design for 50MV/m [2]. For the 9-cell cavity, we have taken 2 steps. The step-1 focused on the proof of 50MV/m on 9-cell using bare 9-cell cavities, which had no end group on beam tubes. End group means HOM couplers, RF input coupler port, and RF pick-up antenna port. The step-2 aims the actual ILC. Figure 1 shows bare and full ICHIRO 9-cell cavities.

CURRENT STATUS OF ICHIRO 9-CELL CAVITIES

Surface preparations

Our current surface preparation recipe for ICHIRO cavities are consists of centrifugal barrel polishing (CBP, ~100μm), light chemical polishing (CP, 10μm), annealing (750C° x 3hrs), electropolishing (EP, 80+20μm), flash EP (3μm, fresh acid, no circulation), post EP cleaning, HPR, and baking (120C° x 48hrs). We will describe about post EP cleaning later. This recipe garantees 45MV/m: 46.7± 1.9MV/m with ICHIRO centre cell singles [3].

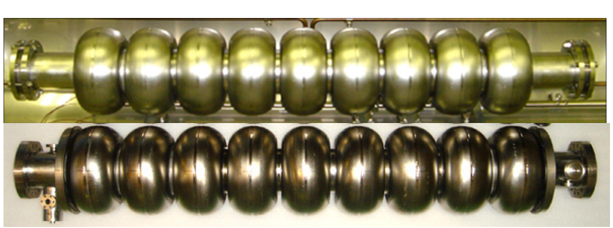

Figure 1: ICHIRO 9cell cavities, Top: ICHIRO#5, bare cavity, Bottom: ICHIRO#7, full cavity.

#fumio.furuta@kek.jp

S0 study on ICHIRO#5, bare cavity

We sent ICHIRO 9-cell #5 to Jlab as S0 tight loop study. In S0 study, cavities will be exchanged and tested at each laboratory. We can cross check the cavity performance, the yield and also compare the facilities. KEK staffs visited and joined the activities of ICHIRO#5 at Jlab. Figure 2 shows the summary of S0 study on ICHIRO#5 done by Jlab and KEK. The maximum gradient 36.5MV/m had achieved at Jlab and 33.7MV/m at KEK so far. Average Eacc are similar, so we confirmed that our KEK LL facilities are not so different from Jlab. [4]

S0 study on ICHIRO#7, full cavity

We fabricated two full ICHIRO 9-cell cavities, I9#7 and I9#8 which have full end group on beam tubes. I9#7 once measured at KEK but limited by FE. After VT, we found a defect on beam tube; it might be a source of FE. We ground it by mini-grinder, and then sent ICHIRO#7 to Jlab for S0 study. VT as received was already done at Jlab. Cavity was just rinsed at Jlab, no chemical treatments. Figure 3 shows the results of VT as received. Gradient was improved from 13MV/m at KEK to 21MV/m at Jlab.

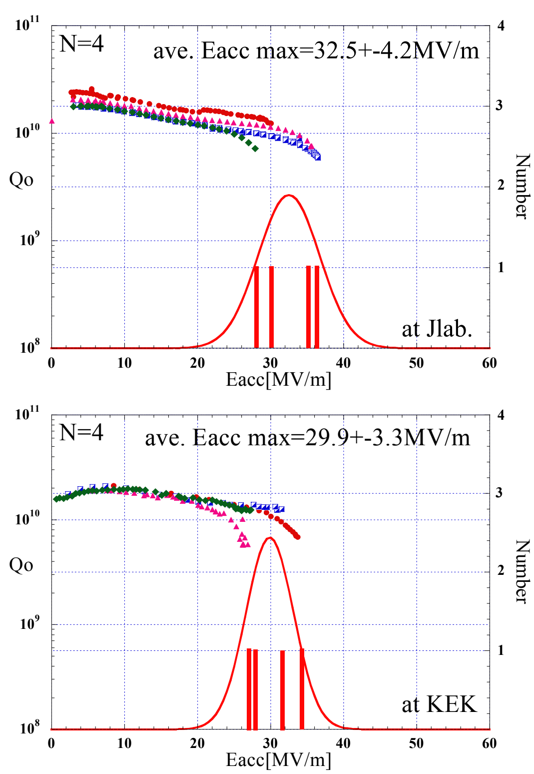

Figure 2: Summary of S0-stuidies on ICHIRO#5, Top: for Jlab, Bottom: for KEK.

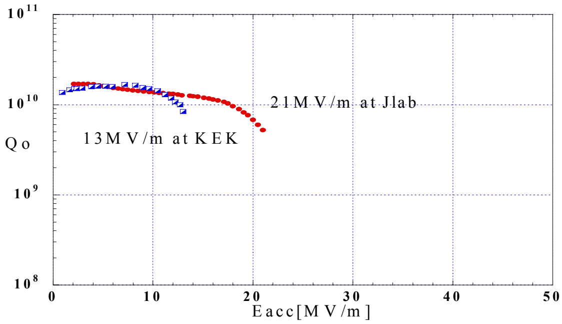

Figure 3: Results of IHCIRO#7 VT as received.

Mechanical grinding mark still remains on beam tube, so cavity might be still limited by FE. Next EP will improve it. S0 study on ICHIRO#7 will start from June 2010. KEK staff will visit and join the activities at Jlab again.

PUZZLE OF 9-CELL LIMITATIONS

In the S0 study of ICHIRO#5, the average gradient was still limited around 30MV/m. The main question is why the recipe which well established from single cell studies doesn't work for 9-cell cavities. Table 1 shows our concerns for the 9-cell limitations. The columns (1) ~ (3) relate to fabrications, preparations, and vertical test, respectively. Some subjects are common to 9cell and single, some are special to 9-cell as the field flatness [5]. We will describe several subjects here, not all, because spaces are limited.

Defects

Cavity was fabricated by electron beam welding (EBW). It would be difficult to guarantee the defect free EBW seam. We grind mechanically all cavity inside surface include EBW seams by CBP. After CBP, cavity inside seems to be no defects on surface and EBW seams. But we sometimes found emerged defects on the equator EBW seam after repeating EP+VT. Our EBW defect might be much deeper. These defects could cause local field enhancement or field emission, and then cavity might be limited at low gradient. We are investigating more reliable EBW conditions for defects free or less. One solution of that is EBW from inside. Some information about inner EBW can be seen in reference [6].

Sulphur contaminations during EP process

Sulphur is well known contaminations generated during EP. It is easily found on cathode bag after EP for instance. We confirmed that sulphur contamination caused the scatter of performance from single cell studies [3]. To understand the mechanism of sulphur generation, we made gas sampling during EP process, and found SO_2 and H_2S are generated. It is well known that these gases react with each other and generate sulphur. We sampled these gases for various EP voltages. Figure 4 shows the detected gas level vs. EP voltages. There is a threshold around 15V. When we did low voltage EP less than 14V, there are no visible sulphur on the cathode bag and rotary sleeves of EP machine. Generation of sulphur can be suppressed by low voltage EP.

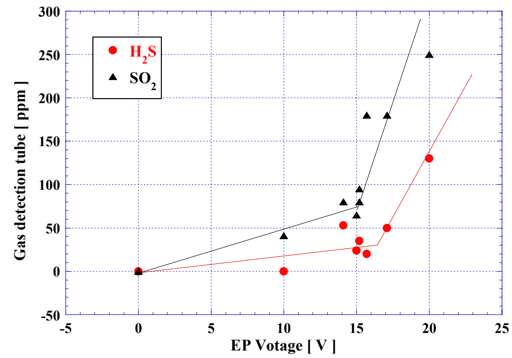

Figure 4: Gas detection level vs. EP voltage.

Post EP cleaning

From end group single cell cavity studies, we found that the rinsing after EP, so called post EP cleaning, is important. We focused on sulphur contaminations at first stage, so we tested degreasing and ethanol rinsing which can dissolve sulphur. Then we understood the difficulties of rinsing with complex structures like HOM couplers. We tested wiping, steam cleaning, and horn rinsing. Those post EP cleanings aim to strengthen the rinsing for end groups. More studies about post EP cleaning and HPR can be seen in [7, 8]

Evacuation during VT

Our cavities were usually closed by metal valve during vertical test. Single cell has no problem with this way, so we did same way for 9-cell. Sometimes 9-cell was limited by FE triggered by multipactings. This triggered FE was cured by additional HPR in many cases. But when we didn't bake cavity after additional HPR, FE happened. We tested cavity again after additional HPR + short baking for degassing, FE was cured. We considered about the mechanisms of triggered FE as follows. Some electrons emitted by MP were accelerated by a multi cell and got high energy. The impact of these electrons on surface might cause a local heating resulting in quench or trigger FE. The residual gas in the cavity might be source of the MP. We set ion pump (200L/s) on top flange of stand and evacuation line to cavity for improving the residual gas level. We started 9-cell VT with I.P. evacuation. Figure 5 shows 9-cell cavity VT stand and evacuation line.


Figure 5: 9-cell VT stand

Table 1: Puzzle of 9-cell cavity limitations.

	Subjects	Cause	Countermeasures	Results, status
(1)	**Defects**	Conditions of EBW	Inside EBW, CBP	Inside EBW is better than outer EBW. See poster WEPE011.
(2)	**Field flatness**	Special to multi cell	Re pre-tuning after EP	96% okay, Improved quality of data.
	Contamination of EP	Sulphur, Oxide	Low voltage EP, Post EP cleaning	Understand of mechanism of Sulphur generation. No visible sulphur after EP.
	Post EP cleaning	Complex structure of end group	Ethanol rinse, wiping Steam cleaning, Horn rinse	Achieved 48MV/m w/ single. Q-slope remains. See WEPE005.
	HPR	Time is short? Procedures?	Long time HPR Carful rinse of end-group	Need more statistics. See poster WEPE010.
(3)	**Initial Pumping**	Contaminations by pumping turbulence	Slow pumping	Need more statistics.
	Evacuation during VT	Gas adsorption trigger MP/FE	Evacuation by I.P.	VT w/ I.P. on going. Need more statistics.
	Cooling down	Large ΔT made local gas adsorption.	Uni-cooling	ΔT is well controlled (<6K). Not yet get clear results

VT RESULTS WITH EVACUATION

. We measured ICHIRO#5 with and without evacuation. Figure 6 shows the first results. The maximum gradients were almost same: 25MV/m. Figure 7 shows the comparison of statistics for VT w/ and w/o evacuation at KEK. We collected the data for VT w/ evacuation only three so far. Some improvement can be seen in total process time. It seems to be shorter ~10% compared with VT w/o evacuation. But still there is no big impact on gradient up to now. We will continue evacuated VT and collect more statistics.

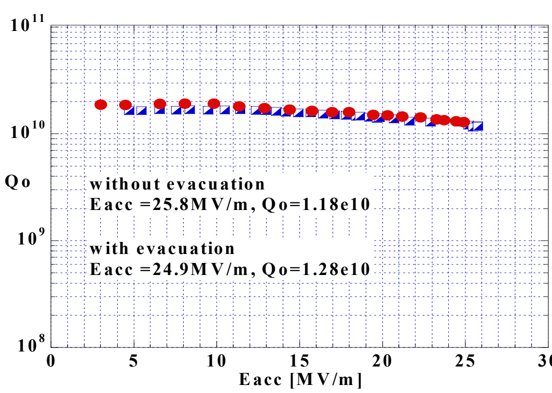

Figure 6: 1st VT results of w/ and w/o evacuation.

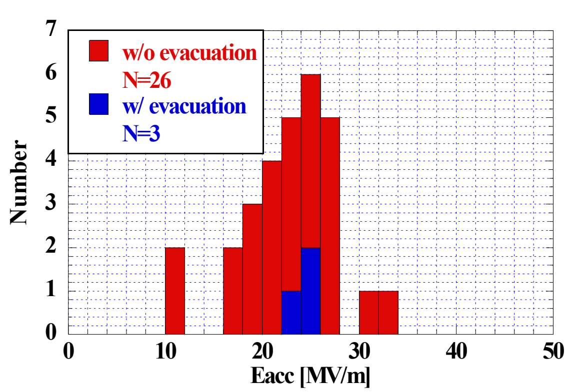

Figure 7: Statistics for VT results w/ & w/o evacuation.

SUMMARY

We are struggling with ICHIRO 9-cell cavities to solve the puzzle of 9-cell limitations. One answer might be found in VT with evacuation, but not yet get clear data and need more statistics. S0-study for ICHIRO#7 will start from next month at Jlab. We would like to thank to Jlab and KEK ILC office for collaboration of S0 study on ICHIRO 9-cell cavities.

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