S0 TIGHT LOOP STUDIES ON ICHIRO 9-CELL CAVITIES

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Abstract

S0 tight loop studies were done on ICHIRO 9-cell cavity #5 at Jlab and KEK. This cavity has no end group on beam tube. Cavity processes and vertical tests were repeated several times. The maximum gradients have achieved 36.5MV/m at Jlab, and 33.7MV/m at KEK so far. Now we are struggling with the puzzle why the results of singles do not work well on 9-cell cavities.

INTRODUCTION

We have continued high gradient R&D of KEK low loss shape (ICHIRO shape) using both of single and 9-cell cavities at KEK [1]. We have succecefully demonstrated the principle proof of 50MV/m with ICHIRO single cell cavities [2]. The both centre and end cell shapes of ICHIRO has no problem on RF design for 50MV/m [3]. In those studies, we established the high yield surface preparation recipe [4]. But when we applyed the recipe on 9cell cavities, it did not work well. The gradient of 9-cell still limited less than 36.5MV/m.

SURFACE PREPARATION RECIPE

Current best recipe for ICHIRO single cells consists of centrifugal barrel polishing (CBP, ~100μm), light chemical polishing (CP, 10μm), annealing (750C*3hrs), electropolishing (EP, 80+20μm), flash EP (3μm, fresh acid, no circulation), ethanol rinsing, wiping with degreaser, HPR, and baking (120C*48hrs). This recipe garantees 45MV/m: 46.7±1.9MV/m with singles [3, 4]. Figure 1 shows some photos of processes.

ICHIRO 9CELL CAVITIES

We have taken 2 steps in the development of ICHIRO 9-cell cavities. The step-1 focused on the proof of 50MV/m with 9-cell using bare 9-cell cavities, which had no end group on beam tubes. The step-2 aims the actual ILC. We fabricated full 9-cell cavities which had full end group on beam tubes [5]. Old ICHIRO had problems on end group, so we re-designed it for new-ICHIRO and fabricated [6]. In this paper, we reported the results of new-ICHIRO 9-cell bare cavity (Figure 2).

Figure 2: new ICHIRO 9-cell #5, bare cavity for step-1

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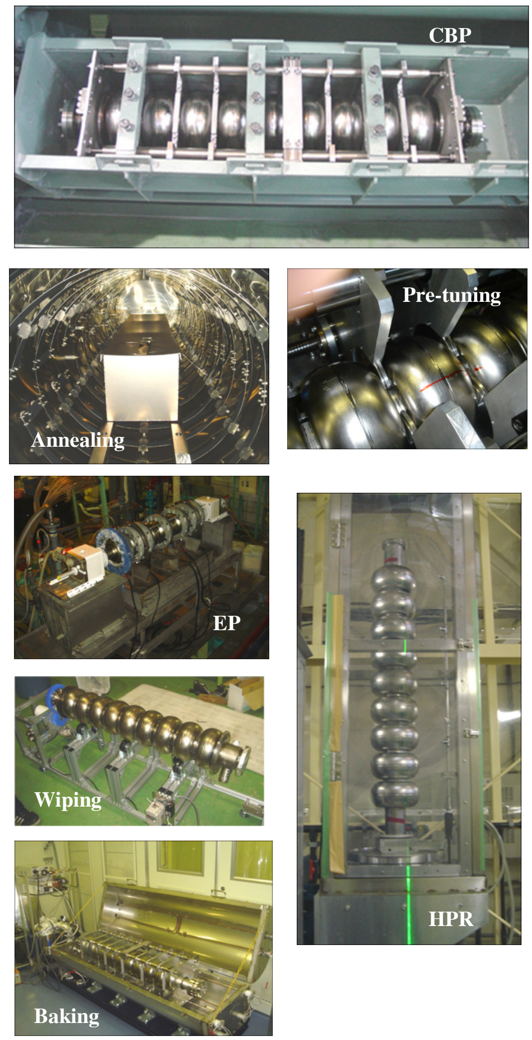

Figure 1: Cavity processes at KEK

S0 TIHGT LOOP STUDY ON ICHIRO

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. Jlab facility has been refined by so many mass-production experiences: CEBAF, CEBAF up-grade, SNS. On the other hand, our facility has not so many experiences. It is good chance to see our facilities how work. ICHIRO#5 was processed and tested 7times at Jlab. 3times were included EP, others were not, just rinsing or re-evacuation. KEK staffs went and joined the activities of ICHIRO#5 at Jlab. After that ICHIRO#5 was sent back to KEK. We also did tight loop test at KEK. Figure 3 shows the best results of ICHIRO#5 at Jlab and KEK. The maximum gradient 36.5MV/m had achieved at Jlab, and 33.7MV/m at KEK so far. Figure 4 shows the statistics of VT but the results contains trivial mistakes are removed. The maximum and the average gradient between Jlab and KEK were not so different. We confirmed our facilities were not so bad.

PUZZLE OF 9-CELL

In the S0 study at KEK, we applied the well established recipe from single cell studies to the 9-cell cavities. But the gradient still limited less than 34MV/m at KEK. We considered what differences are there between 9-cell and single. Table 1 at last page shows our concerns for the performance. Blue columns have understood with enough statistics. Yellows need more statistics. Greens are under testing. Some concerns are common to 9cell and single, some are special to 9-cell as the field flatness. We should solve this “Puzzle” one by one to achieve high gradient and high yield with 9-cell cavities. Details of sulphur contaminations and the field flatness are reported another papers in this proceedings [7, 8].

Hint of the Puzzle

The 9-cell performance sometimes limited by triggered field emission (FE) by multipacting (MP). Figure 5 shows an example results. We considered the mechanisms of this 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 to quench or trigger FE. One should remain FE electron get more energy in 9-cell cavities. We got some hint from the tight loop test of rinsing for 9-cell. When we make retest, if the cavity has been done EP and baked already, we don’t need to bake it again after HPR. It is well demonstrated with single cell cavities. So when we started the tight loop test, cavity wasn’t bake at first. In that case, triggered FE happened. We suspected about the residual gas in the cavity, short baking for degassing was done after the rinsing. FE was not triggered by MP (Figure 6). We considered that one of sources of triggered FE might be the residual gas in the cavity. In addition to short baking, we also modified the cooling method. If we cool down the cavity without care, the bottom cell is cooled quickly. The adsorption gas is concentrated very much at bottom. This condensed gas might cause MP and easily trigger FE. So we improved the cooling method and made uniform cooling from top to bottom. The temperature difference is less than 6K now. The processing time seems to be shorten by this way. But still it is not enough to cure triggered FE perfectly.

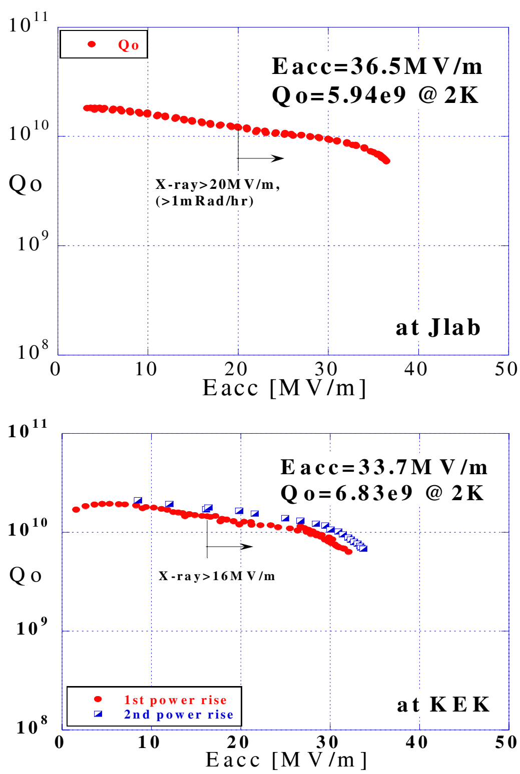

Figure 3: The best results of S0-study for ICHIRO 9-cell #5. Top: VT at Jlab, Bottom: VT at KEK

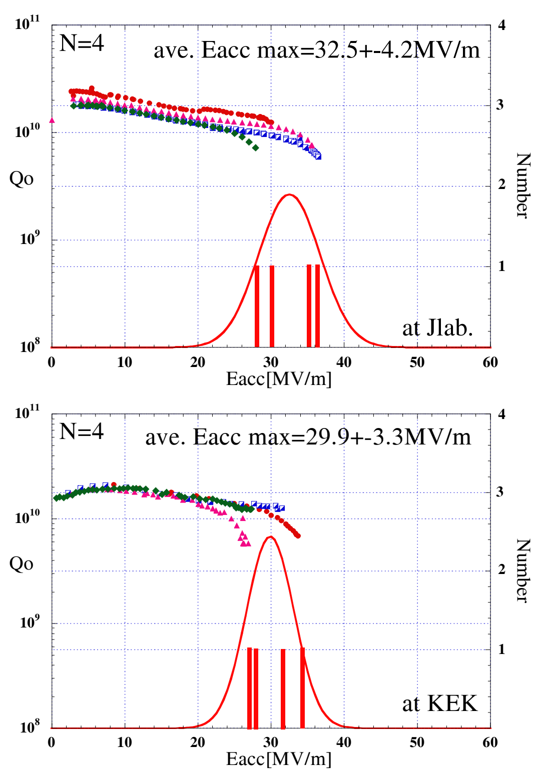

Figure 4: Summary of S0-studies on ICHIRO#5.

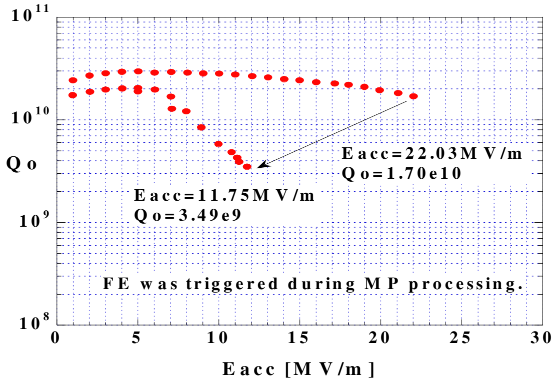

Figure 5: Gradient degradation by triggered FE

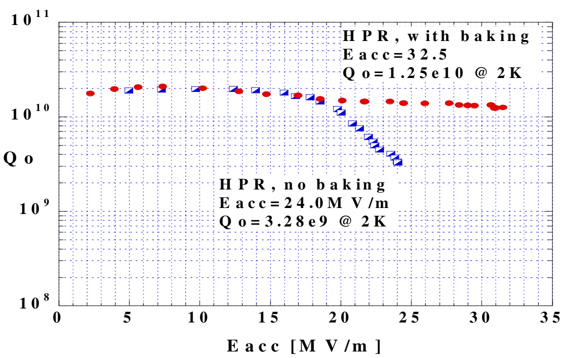

Figure 6: Baking effect after HPR

Evacuation During VT

Our cavity was usually closed by metal valve during vertical test. Single cell has no problem with this way. This closed VT is very useful for how quickly ready to VT in a week. But for the 9-cell, the evacuation during VT might be an answer for the puzzle. We changed the way in order to reduce the residual gas. We evacuated the 9-cell cavity by ion pump (200L/s) during VT. We measured ICHIRO#5 with and without evacuation. First we measured cavity without evacuation. The cavity was warmed up and connected to evacuation line. Before opened the cavity valve, we baked the evacuation line. And then, we measured the cavity with evacuation. Figure 7 shows the results. The maximum gradient were almost same: 25MV/m. The results of pass-band measurements were also same (figure 8). Total process time was shorten about 10% by evacuation (figure 9). The results might effected by the memory of the first closed VT. We should measure cavity with evacuation first. We will collect more data about the evacuated VT. We are also investigating much effective evacuation method for VT.

SUMMARY AND AKNOWLEDGEMENT

We did S0 study on ICHIRO 9-cell #5 at Jlab. and KEK. So far, ICHIRO#5 achieved 36.5MV/m at Jlab, and 33.7MV/m at KEK. We are now struggling with the puzzle of 9-cell cavities. Why the recipe of single cells does not work well on 9-cell? We are investigating the evacuation effect during VT.

We would like to thank to Robert Rimmer, Jlab and KEK ILC office for collaboration of S0 study on ICHIRO#5.

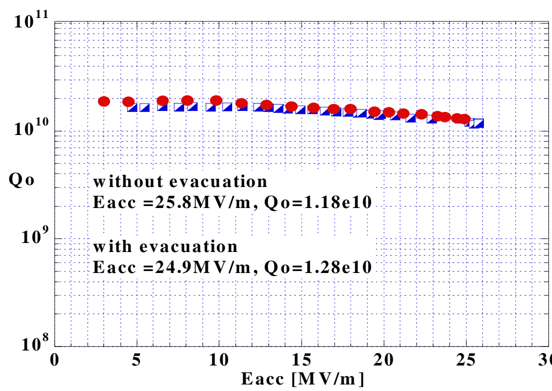

Figure 7: VT results, with and without evacuation.

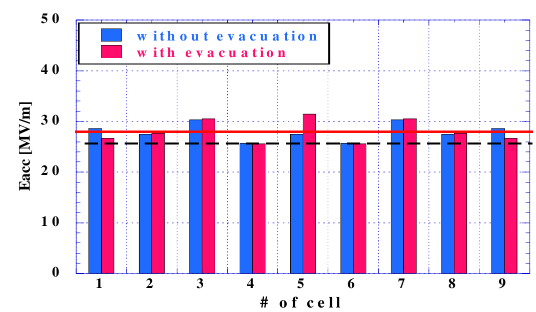

Figure 8: Pass-band measurement results with and without evacuation.

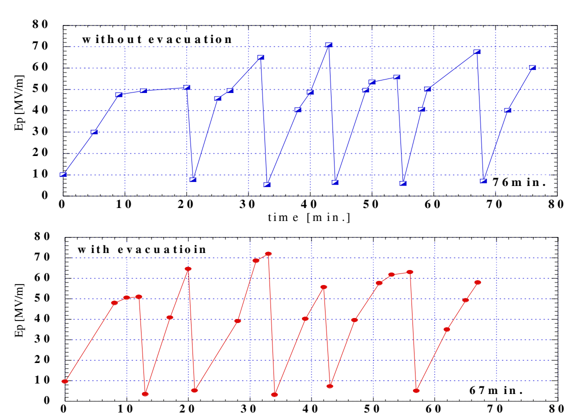

Figure 9: The total processing time with and without evacuation.

Table 1: Puzzle of 9-cell cavities. Blue : statistics okay, yellow: need more statistics, green: under testing.

Subjects	Cause	Countermeasures	Results, status
EP	Sulphur contaminations	Degreasing, ethanol rinsing Understanding of Sulphur generation at EP process	Understand of mechanism of sulphur generation. No visible sulphur after EP.
PW (HPR)	Low quality imperfect control	Monitoring of TOC & Bacteria	No problem at single cell results.
Cavity cooling	Fast cool: large $\Delta T > 50K$ locally gas absorption MP/FE	Slow cooling Uniform cooling	$\Delta T < 6K$ Shorten processing time.
Field flatness	Special to multi cell	Re-pre tuning after EP	96% in hand, Improved data quality.
HPR time	Too short? (4 ~ 6hrs)	Long time HPR (~10hrs)	Not yet get clear effect.
Evacuation speed	Contaminations by pumping turbulence	Slow evacuation	Need statistics.
HOM	Difficulty of rinsing, Multipacting	Wiping, ethanol rinse	Achieved 48MV/m w/ single cell cavity.
Closed VT with metal valve	Trigger MP/Field emission	Evacuate cavity during VT	VT ongoing w/ IP (200L/s).
EBW	Accuracy of cup Conditions of EBW	CBP、inside EBW	Start test of EBW.

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