S0-STUDIES ON ICHIRO 9-CELL CAVITIES IN COLLABORATION WITH KEK AND JLAB

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Abstract

In 2008, KEK and Jlab did the collaboration of S0-study on bare ICHIRO 9-cell #5 which has no end groups on beam tubes. Maximum gradients of 36.5MV/m at Jlab and 33.7MV/m at KEK were achieved so far. In this year, 2010, KEK and Jlab started new S0-study collaboration on full ICHIRO 9cell #7 which has full end groups on beam tubes. As S0 tight loop test, surface treatments and vertical tests were repeated on ICHIRO#7 at Jlab. We will report the results of that.

INTRODUCTION

We have continued high gradient R&D of KEK low loss shape (ICHIRO shape) using both of single and 9-cell cavities. We have succecefully demonstrated the principle proof of 50MV/m with ICHIRO single cell cavities. The both centre and end cell shapes of ICHIRO has no problem on RF design for 50MV/m. For 9-cell cavity, we have taken 2 steps. The step-1 focused on the proof of 50MV/m 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 ACD cavity using full 9-cell cavities, which have end groups on beam tubes. Figure 1 shows bare and full ICHIRO 9-cell cavities.

Surface Preparation Recipe for ICHIRO Cavities

Our current surface preparation recipe for ICHIRO cavities consists of centrifugal barrel polishing (CBP, ~100μm), light chemical polishing (CP, 10μm), annealing (750°C x 3hrs), electropolishing (EP, 80 + 20μm), flash EP (3μm, fresh acid, no circulation), post EP cleaning [1, 2], HPR, and baking (120°C x 48hrs). This recipe garantees 45MV/m: 46.7±1.9MV/m with ICHIRO centre cell singles.

S0 Study on ICHIRO#5

In 2008, 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 data and also compare the facilities. KEK staffs visited and joined the activities of ICHIRO#5 at Jlab. The maximum gradient 36.5MV/m had achieved at Jlab and 33.7MV/m at KEK so far. Average Eacc of 4 RF tests in each lab were 32.5±4.2MV/m and 29.9±3.3MV/m respectively. We confirmed that our KEK ICHIRO facilities are not so different from Jlab [3]. Activities on ICHIRO#5 are continued at KEK [4].

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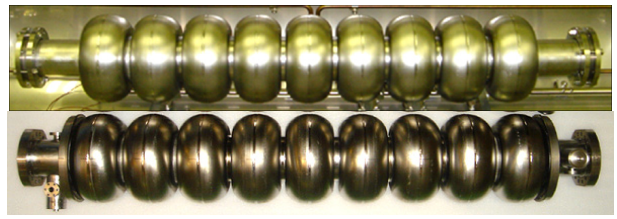

Figure 1: ICHIRO 9cell cavities. Top: ICHIRO#5, bare cavity. Bottom: ICHIRO#7, full cavity.

NEW S0-STUDY ON ICHIRO#7

We fabricated two full ICHIRO 9-cell cavities, ICHIRO#7 and #8. ICHIRO#7 was processed by ICHIRO recipe and tested at KEK. Pi-mode gradient was limited by FE at 12MV/m. From the inside inspection after VT, we found a defect on beam tube; it might be a source of FE. We ground it off by mini-handy grinder, and then sent it to Jlab for new S0 study. KEK staffs visited Jlab again and joined the activities.

Hardware Preparation

To process ICHIRO#7 at Jlab, several hardware were prepared. Jlab's cavity cage was modified to fix ICHIRO#7 with KEK's cage. ICHIRO#7's beam tube flange has MO seal flange [5], so we need to make adapters between MO flange and EP machine to install the cavity. We also made new EP cathode for ICHIRO#7. Figure 2 shows EP set-up of ICHIRO#7. For HOM ports and Pt port, we used ILC standard Al gasket as sealing. Those ports of ICHIRO#7 were made of Nb. This sealing was first challenge. Leak tightness of this combination was demonstrated in this S0-study. Fundamental input coupler port was sealed with indium wire. We could not use ILC standard Al gasket here because of the difference of flange shape. MO flange was sealed with indium plated Al gasket.

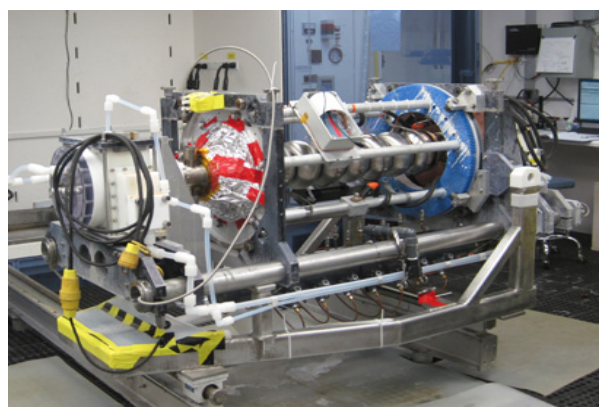

Figure 2: ICHIRO#7 EP set-up at Jlab

VT Results as Received

After shipping from KEK to Jlab, ICHIRO#7 was inspected inside first and flatness measurement was also done. The flatness was 94%; no degradation was happened during shipping. It was processed by ultrasonic cleaning (USC) with degreaser and HPR, and then tested. Figure 3 shows the both results of VT as received (red dots in the graph) at Jlab and VT at KEK before shipping (black dots in the graph). Blue dots in the graph show the radiation level of VT at Jlab. Maximum gradient was improved from 12MV/m to 21MV/m; but limited by FE. Mechanical grinding mark still remains on beam tube, so this might have some responsibility for FE limitation. The flatness was kept with 93% after VT.

VT Results after 1st EP at Jlab

For the 2nd RF test, 25μm EP was done. As post EP cleaning, wiping and brushing on end groups and USC were done. In total, 6cycles HPR were done. Unfortunately, the indium seal at input coupler port was melted and leak was happened because of failure baking process. Cavity inside was contaminated by melted indium. We did nitric acid soaking to remove indium contaminations and HPR again. Then cavity was baked with 120°C for 48hrs successfully, and tested. Figure 4 shows the results. Severe FE was induced during the processing around 15MV/m, and gradient was limited 11MV/m. We set Oscillating Superleak Transducers (the OST) and monitored the second sound produced by the cavity quenched to identify the quench location [6]. OST indicated the quench location was around the top end group.

VT Results after re-HPR

Cavity was rinsed again by HPR then tested to confirm the limitation came from contaminations or defects. Figure 5 shows the results. The maximum gradient was improved up to 21MV/m. This test also limited by severe FE. After VT, we did cavity inside inspection. We found contaminations from top side HOM to cell. The contaminants were sampled and analyzed by EDX and SEM. These contaminants consisted of Si, S, and Cl. Si and S were components of degreaser. But we did not found yet where Cl came from. We cleaned these contaminations by wiping with BCP acid. Flatness was 94% after VT, so we did 2nd EP without tuning.

VT Results after 2nd EP at Jlab

To avoid any affects of previous contaminants, we removed 30μm as 2nd EP at Jlab. Post EP cleaning and HPR cycles were same as last EP. At the leak check, small leak was found at top HOM sealing. We disassembled the top HOM blank and found very small defect on the Nb flange surface. ILC standard Al gasket is very sensitive to defect on seal surface, we should be very careful against the seal surface and the edge of Al gasket. We sealed this flange with indium. HPR and final assembly were done again. Leak tightness was confirmed

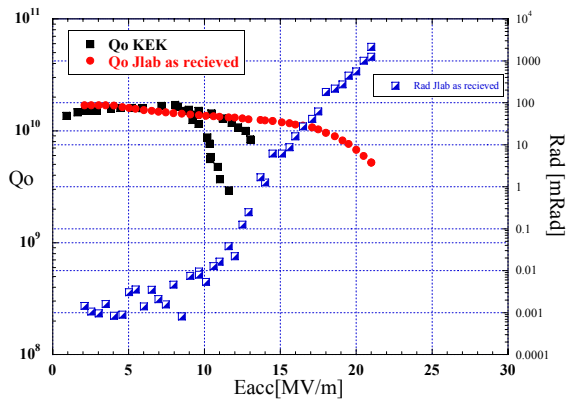

Figure 3: VT at KEK and as received at Jlab.

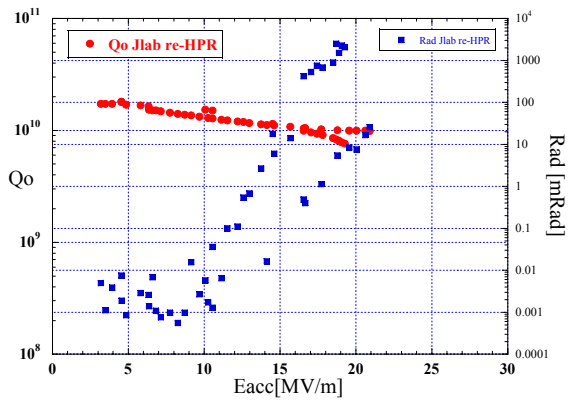

Figure 5: VT after re-HPR at Jlab

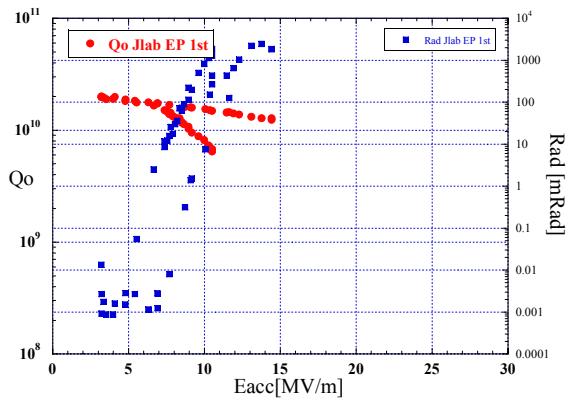

Figure 4: VT after 1st EP at Jlab.

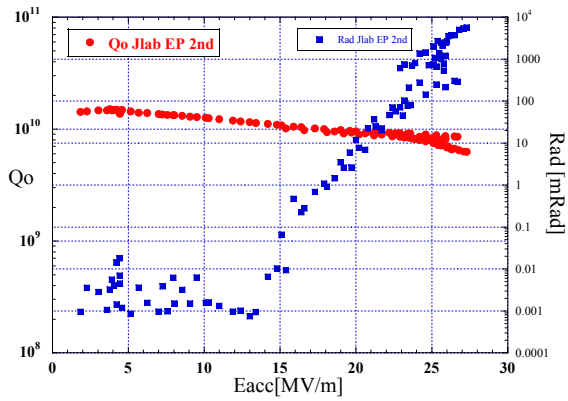

Figure 6: VT after 2nd EP at Jlab.

at room temperature. Cavity was baked and tested. Figure 6 shows the results. Maximum gradient of 27MV/m was achieved. 2nd sound monitoring was also done. OST indicated that the quench location was around 3rd or 4th cell counted from input coupler port side. After VT, flatness measurements and optical inspection were done. The flatness was degraded from 94% to 87%. A dog-born shaped discoloration area was observed near HOM can on Pt port side. This feature was not observed before VT. Twin pit were also found on beam tube near the Pt port.

DISCUSSION

Current limitation of ICHIRO#7 was the quench at 27MV/m in pi-mode. From the inspection point of view, several features in the end group seem to relate to the limit, while OST measurements said quench did not happen in the end group. So the defects in the end group might be source of electron. Those electrons were accelerated and bombard cavity inside surface resulting in the quench. The high radiation level monitored through the VT also suggests the electron bombardment is very severe. We also did pass-band measurement and results were summarized in figure 7. Pass-band results of VT after 2nd EP was not consistent with pi-mode results. This might be caused by flatness degradation during 2nd EP and VT. We need to eliminate the features and defects in the end group before next EP process. We also need to understand why flatness was degraded about 7% and keep the flatness high during all processes.

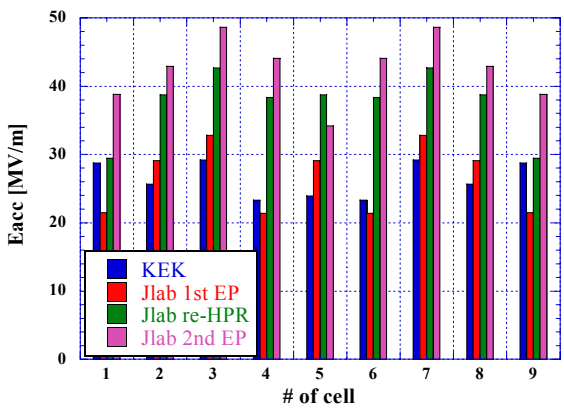

Figure 7: Summary of pass-band meas.

SUMMARY

The results of S0-study on ICHIRO#5 in 2008 showed there were not so big differences between Jlab and KEK ICHIRO facilities. We started new S0-study on ICHIRO#7 at Jlab in 2010. ICHIRO#7 was already tested 4 times at Jlab so far. Figure 8 shows the summary of Qo-Eacc curve. 2 of 4tests included EP, another 2tests were done by just re-rinsed. For these tests, we prepared several hardware. For the instance we made EP sleeve adapters and EP cathode for ICHIRO#7. All commissioning to process ICHIRO#7 at Jlab was finished. Maximum gradient of pi-mode was improved up to 27MV/m so far (Figure 9). From the pass-band meas. each cell are expected to reach more than 35MV/m. Cavity limitation seems to relate to end groups, several features are still seen in end groups. We will continue this collaboration and solve end group issues to achieve high gradient by additional EP processes. As new impact, it should be noted that the leak tightness of the combination of Nb flange and ILC standard Al gasket was demonstrated at HOM and Pt ports. We would like to thank to Jlab and Jlab staffs for collaboration of new S0 study on ICHIRO#7.

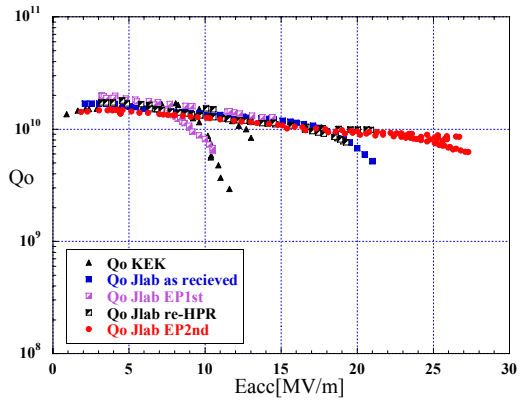

Figure 8: Summary of Qo vs. Eacc.

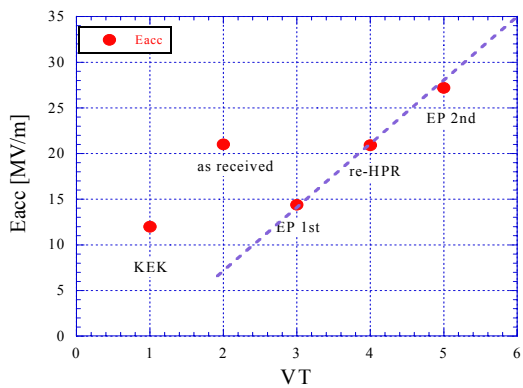

Figure 9: Summary of Eacc max.

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