FABRICATION AND TESTING STATUS OF IHEP03

T.X.Zhao*, J.Y.Zhai, H.J.Zheng, Z.Q.Li, Z.C. Liu, S. Jin, Y.L.Liu, J.Gao
IHEP, Beijing, China
H. Yuan, H. Yu, J.X. Wang, BIAM, Beijing, China
Eiji Kako, Mineyuki Asano, KEK, Ibaraki , Japan

Abstract

As a SRF 9-cell cavity collaboration project of IHEP and KEK, a Tesla-Like (STF-TYPE) cavity was fabricated (figure 1). The cavity has used fine grain niobium from Ningxia, China, fabricated and tumbling at IHEP, then processed and tested at KEK. The cavity was processed through IHEP (tumbling) and KEK SRF infrastructures, using FNAL tumbling recipe [1] and KEK baseline processing recipe [2]. After all, the cavity fabrication, processing, test performance and gradient limitation results are reported in this paper.

INTRODUCTION

Superconducting RF is a key technology for most accelerators in operation or under construction by IHEP. It is crucial for all the future planned projects. IHEP had built a 1.3GHz SRF accelerating unit to demonstrate the SRF technology, which the key components have been fabricated and tested successfully [3]. To further improve the 1.3GHz cavity technology, the IHEP03 cavity was made together with KEK.

The IHEP-03 was first fabricated in China. After tumbling at IHEP, the cavity was sent to STF, which optical inspection was done by Kyoto camera. The main processing procedures include an 80 μm tumbling at IHEP to mirror surface. Processes taken place at KEK include local grinding, 5μm Pre-EP, 100μm EP-I, heat treatment 750°C for 3 hours, pre-tuning to 93%, EP-II 20μm, ultrasonic cleaning, HPR and bake 140°C for 48 hours. Optical inspection was done again after the vertical test. Due to imperfect quality seams, the gradient result was 16.8MV/m.

CAVITY FABRICATION

Based on the previous cavity fabrication experience, the half cell and the dumbbell processed pretty well. The Tesla-like cavity's half cell has a step feature at its equation to ensure the half cell precisely match up with each other, but it is difficult for our EBW factory to weld the step. We fabricated the half cell by the final drawing and did not consider the shrinking caused by welding. As the cavity frequency cannot be controlled within the desired range, we controlled only the mechanical dimensions [4].

We made the high-order mode coupling pickup hole using pull method. This is the first time we use this method. After many experiments, we found the best pulling parameters. Based on the IHEP-02 end group EBW experience [5], the IHEP-03 end group welding were done with better quality.

Because of the step at the equator, we made some test pieces for exercise. Yet, when we welded at the equator, we failed. We discovered the possible reason is due to a poor coordination of the step feature we made. Thus, we machine the step feature again and adjust the coordinate style. Nevertheless, when we were welding the cell#5, a hole appeared. To tackle the problem, we made a same-shaped niobium sheet for the hole, and welded it to the cavity.

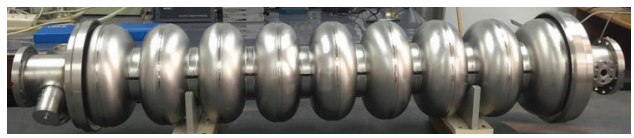

Figure 1: TESLA-LIKE 9cell cavity-IHEP03.

After welding, leak check and frequency measurement we done. The frequency is 1307.3855 MHz, the field flatness is 81.7%.

CAVITY PROCESSING

The main processing procedures include:

- tumbling at IHEP to mirror surface 80 μm
- Then at KEK, local grinding
- 5μm Pre-EP
- 100μm EP-I
- heat treatment 750°C for 3 hours
- pre-tuning
- 20μm EP-II
- ultrasonic cleaning
- HPR
- bake 140°C for 48 hours.

Tumbling

Due to the poor welding quality and the many splashes, we tumbled the cavity at IHEP. The FNAL tumbling recipe was used, which was the same recipe used by IHEP02. Two rounds of tumbling were conducted and 80 μm was removed. After the tumbling process, inner surface of the cavity was inspected by IHEP camera. Only one defect was found in cell#9, and the cavity was shipped to KEK for the next process.

Local Grinding

When the cavity arrived KEK, we observed the inner surface by Kyoto camera. The defect in cell#9 was found, located at 315 degree as we discovered previously; and we found several extra defects. After grinding the defect at cell#9 315 degree, it becomes bigger. We concluded this defect is a big hole in the seam, which we cannot see

* zhaotx@ihep.ac.cn

the defect clearly until gridding it. We spent a week time ahead to remove this defect. Due to the time constraint, other minor defects were not processed. The cell#9 315 degree grinding is shown in figure 2.

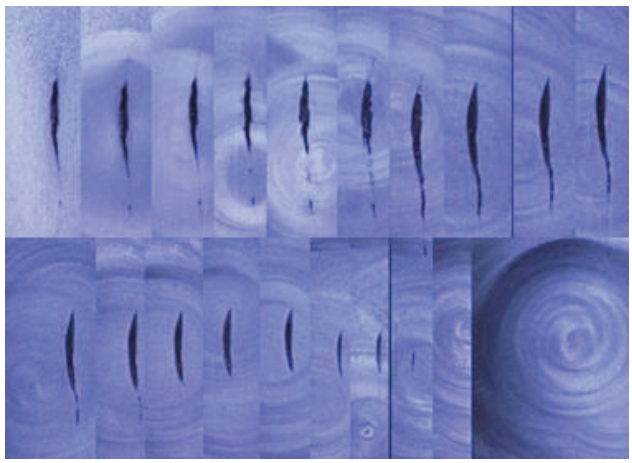

Figure 2: Cell#9 Local Grinding process.

EP & Annealing

After local grinding, we removed 5μm by pre-EP, then 100μm by EP-I. Then, we started heat treatment for the cavity at 750°C for three hours. At 380°C the vacuum pressure of annealing furnace has risen, and at 580°C the pressure reached a peak. We observed the inner surface by Kyoto camera after the EP and annealing, a large number defects appear, which most of the defects dimension were below 0.1mm. The total number of defects is about 1228. Since we cannot remove the defects by local gridding, we decided to proceed to vertical test without processing them.

Pre-tuning

The frequency of the cavity is 1303.651 before pre-tuning, 6 MHz higher than our design; we decided ignore the frequency and tuned the cavity to 93% field flatness. After installing the fixture for the cavity, the field flatness is 92.95% (figure 3).

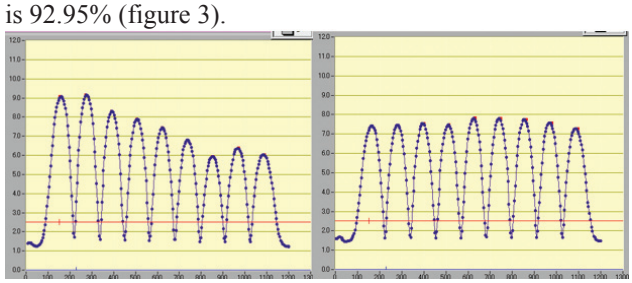

Figure 3: IHEP-03 field flatness before tuning and after installing the fixture.

EP-II& VT Preparation

To avoid the flange sealing leakage, we polished the flange by hand before EP-II. Through EP-II, we removed 20μm. Then we ultrasonic cleaning the cavity with FM20, high pressure water ringing it for 5 hours and assembled it in the clean room. After leak check, we baked the cavity for 48 hours.

VERTICAL TEST

T-mapping system [6] was installed in the vertical test, and we added some thermal sensors on the defect location. The cavity frequency is 1305.446MHz at 2K and quenched at 16.8MV/m at 120 degree in cell#1. The result of the vertical test was shown in figure 4 and figure 5.

We tested the other passband mode. Due to the observed defects, all the other cells could only reach at around 20MV/m.

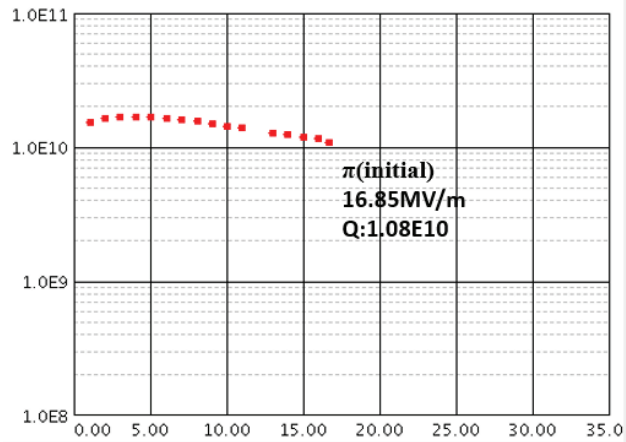

Figure 4: Vertical test result of IHEP-03.

MV / m	Cell 1& 9	Cell 2 & 8	Cell 3 & 7	Cell 4 & 6	Cell 5	Quench Location/Comments
π(initial)	16.85	16.85	16.85	16.85	16.85	Heat @ 1-cell equator 120° X-Ray
π(final)	16.64	16.64	16.64	16.64	16.64	Heat @ 1-cell equator 120° X-Ray
2 π / 9	8.10	19.44	22.28	14.90	---	Heat @ 3&7-cell equator X-Ray
5 π / 9	18.85	12.82	22.24	3.77	23.94	Heat @ 1-cell equator 120° X-Ray
4 π / 9	13.00	17.03	7.41	18.85	---	Heat @ 6-cell equator 240°~270° X-Ray
3 π / 9	12.32	24.64	12.32	12.32	>24.64	Heat @ 2-cell equator 300° X-Ray
$E_{acc,max}$	18.85	24.64	22.28	18.95	24.64	Ave. $E_{acc,max}$=21.54

Figure 5: Cell Gradient by Passband Modes Test.

After vertical test, we observed the quench defect location by Kyoto camera. And we found the number of defects increased from 1228 to 2222. According to figure 6, we believe there may be more similar defects in the seam. Extra tumbling is necessary for this cavity.

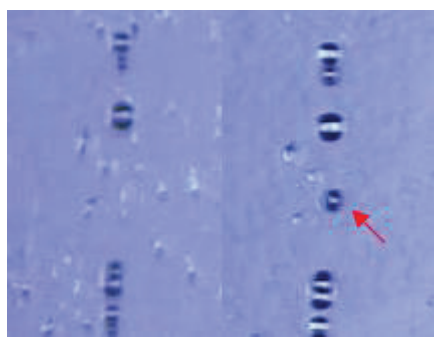

Figure 6: New defects appeared (cell#5.216deg).

ISBN 978-3-95450-147-2

SUMMARY

IHEP has made a Tesla-Like cavity, processed and vertical tested at KEK. The gradient was unsatisfactory because of the imperfect EBW quality. We will tumble to cavity again to try to remove the defects at IHEP. If we can successfully remove all the defects, the cavity will be test again at KEK.

ACKNOWLEDGEMENT

We would like to express our deepest gratitude for the support of Eiji Kako at KEK for this collaboration project, and the other KEK staffs including Kensei Umemori, Motoaki Sawabe, Kouichi Nakamura, Fumihiko Tukada, Jun Sakai, Taisuke Yanagimachi, Shinichi Imada, Hiroki Yamada.

REFERENCES

[1] C. Copper, *et al.*, "Mirror Smooth Surfaces and Repair of Defects in Superconducting RF Cavities by Mechanical Polishing", Superconductor Science and Technology, 26(2013)015011

[2] E. Kako, *et al.*, "Vertical test results on the srf baseline 9-cell cavities at KEK" SRF2007, Peking Univ., Beijing, China, (2007),WEP10

[3] J. Gao, *et al.*, "Status of the IHEP 1.3GHz superconducting RF program for the ILC", IPAC2013, Shanghai, China, Proceedings of IPAC2013 WEPWO018

[4] Z.C.Liu, *et al.*, "IHEP03 fabricatication and test status", IPAC2013, Shanghai, China,(2013) WEPWO022

[5] J.Y. Zhai, *et al.*, "IHEP 1.3GHz low loss large grain 9-cell cavity fabrication, processing and test", SRF2013, Paris, France,(2013) MOP073

[6] Y. Yamamoto, *et al.*, "Cavity Diagnostic System for the Vertical Test of the Baseline SC Cavity in KEKSTF", SRF2007, Peking Univ., Beijing, China, (2007), WEP13.