

SUMMARY OF RESULTS AND DEVELOPMENT OF ONLINE MONITOR FOR T-MAPPING/X-RAY-MAPPING IN KEK-STF

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Abstract

Vertical test for 1.3GHz 9-cell cavity has been routinely carried out over one year since 2008 in KEK-STF. Temperature mapping (T-mapping) system using 352 carbon resistors was introduced to identify the heating location at thermal quenching of the cavity. The T-mapping system identified perfectly the heating location in every vertical test for S1-Global project. As X-ray-mapping system, 142 PIN diodes were used, and the x-ray emission site was detected under heavy field emission. During the vertical test, it is convenient to display the result of T-mapping and X-ray-mapping by online monitor system. For this purpose, the new online monitor system was developed by using EPICS (Experimental Physics and Industrial Control System) and Java script, and introduced in recent several vertical tests. As a data acquisition system, nine data loggers (MW100, YOKOGAWA) are used, and signals from totally 540 channels are stored every 0.1 sec. The online display for T-mapping and X-ray-mapping is updated automatically every 5 seconds. In this report, the summary of T-mapping/X-ray-mapping result and the online monitor system will be described in detail.

INTRODUCTION

The new vertical test facility and the electro-polish (EP) facility were constructed for ILC (International Linear Collider) and ERL (Energy Recovery Linac) project at KEK-STF in 2008. It is possible to do all processes, except annealing, in STF after the delivery of cavities. Successful commissioning of this vertical test system was carried out with AES#001, after solving a few technical issues.

Identification of heating locations during the thermal quenching is an important task of vertical test, in addition to the measurement of $Q_0 - E_{acc}$ curve and maximum gradient. For this purpose, the new T-mapping system was developed and introduced [1], which allows to identify the hot spots with an efficiency close to 100%.

A cavity occasionally quenches due also to field emission, which is caused by the electron bombardment. In this case, an associated x-ray emission would be detected. Recently, an X-ray-mapping system using 120 PIN diodes is completed and attached around each iris region. Correlation was found between the heating and the x-ray emission in the first and third vertical test of MHI#9. In the third test, the pre-heating phenomenon, which level is generally small and appears before quench, was also observed with the x-ray emission. Probably, the electron impact is responsible for the pre-heating

phenomenon in this test.

T-MAPPING AND X-RAY-MAPPING SYSTEMS

Background

When MHI#1-#4, which were developed and produced for STF Phase-1, were vertical-tested in 2006-2007, a simple T-mapping system was used. Although the number of the carbon resistors was only 44, it was possible to identify the heating cell at the thermal quenching [2]. However, it was not possible to identify the heating location at the heating cell, because of the small number. Therefore, it was necessary to develop and introduce the new T-mapping/X-ray-mapping system for the vertical test at STF, which has much more carbon resistors and PIN diodes.

Features

The new T-mapping system has totally 352 carbon resistors and they are regularly attached on the fish-bone type structure. This system was introduced for the vertical test of AES#001 for the first time and it was successful for the identification of the heating location at the thermal quenching. After that, it was used for many vertical tests using MHI#5-#9, which were fabricated for S1-Global project, and it is successful to identify the heating location with the efficiency of 100%.

On the other hand, after the completion of the new T-mapping system, the X-ray-mapping system, which is composed of totally 120 PIN diodes, was also developed for the detection of the x-ray emission at every iris except for cell#3-#4 and cell#6-#7. When a cavity has a heavy field emission, it sometimes has a thermal quenching due to the electron bombardment. In this situation, the heating location and the x-ray emission overlap each other. When the first vertical test for MHI#9 was done, this phenomenon was observed. Moreover, at the third vertical test, the pre-heating phenomenon was observed due to the electron impact.

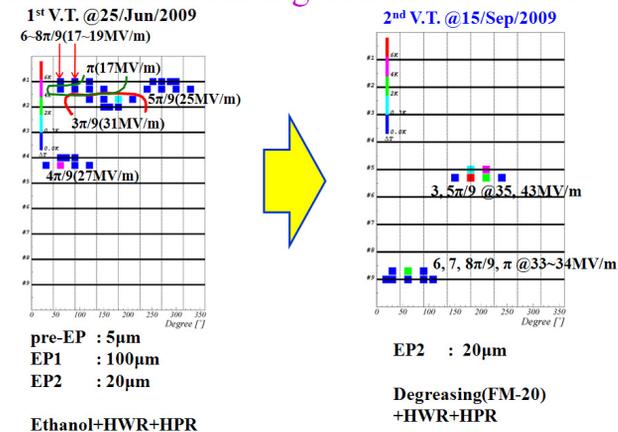
Result of T-mapping for MHI#7-#9

Figure 1 shows the transition of the heating location among the several vertical tests for MHI#7-#9. The heating location and the quench field in π mode were different in every vertical test. This situation is different from that for MHI#5 and #6, which heating location was not changed due to the non-uniform EBW (Electron Beam Welding) seam even after a few EP treatments. This means the EBW quality for MHI#7-#9 was more improved compared to MHI#5 and #6.

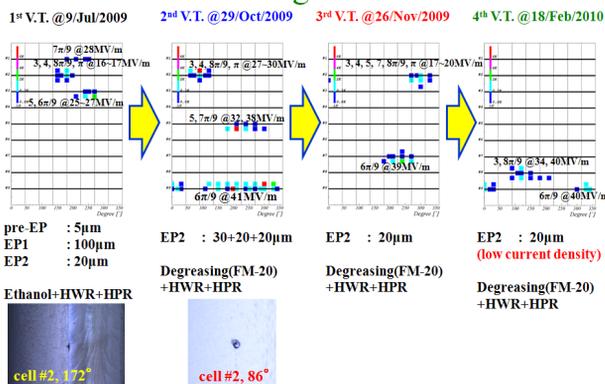
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Two defects, which were one pit (locally ground) and one bump, were observed after the first and second vertical test for MHI#8. However, in the other tests, any defect was not also observed at the heating location. In STF, this is the most common case. The main cause of the field limit was the quench by defect or contamination, which was not observed in many cases. The field emission was the second cause.

Transition of heating location for MHI#7



Transition of heating location for MHI#8



Transition of heating location for MHI#9

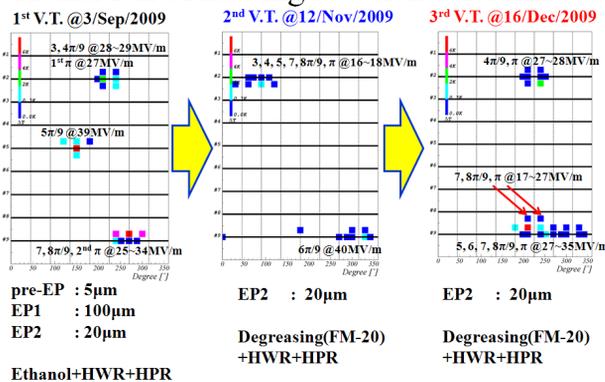


Figure 1: Transition of heating location for MHI#7-#9.

Correlation between T- and X-ray-mapping

Figure 2 shows the comparison between the T-mapping and the X-ray-mapping for the first power rise and second one using π mode in the first vertical test of MHI#9. The heating location at the cell #2 in the T-mapping was not

consistent with the high radiation region in the X-ray-mapping for the 1st power rise, because the field was limited by the thermal quench due to any defect or contamination. On the other hand, for the 2nd power rise, the heating location was transferred to the #9 cell with the higher x-ray emission. This is the typical example of the heating by the field emission. Therefore, the X-ray-mapping is useful to check the correlation with the T-mapping, when the heavy field emission occurs.

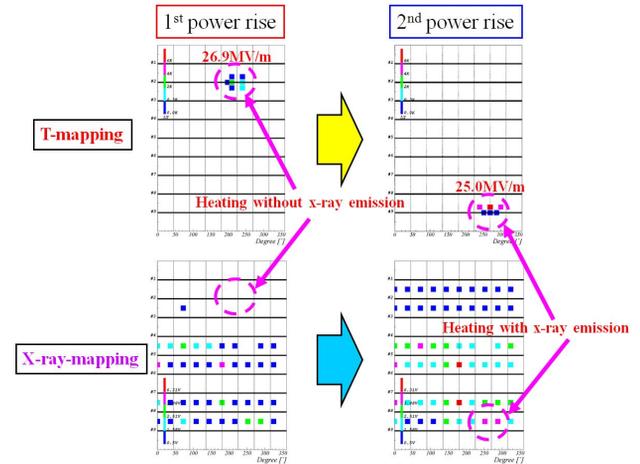


Figure 2: The correlation between the T-mapping and the X-ray-mapping in 1st V.T. for MHI#9.

Pre-heating observed at 3rd V.T. for MHI#9

Figure 3 shows the pre-heating observed at the third vertical test for MHI#9. The left figure shows the time trend, and the right one shows the correlation between the gradient and the heating. In the purple framework of the right figure, the T-mapping at the quench is shown. Before the quench, the pre-heating location was on the meridian of the cell #8 and #9. However, at the quench, the cell #2 was heating. The heating at the quench is higher and pulse-like, compared to the pre-heating.

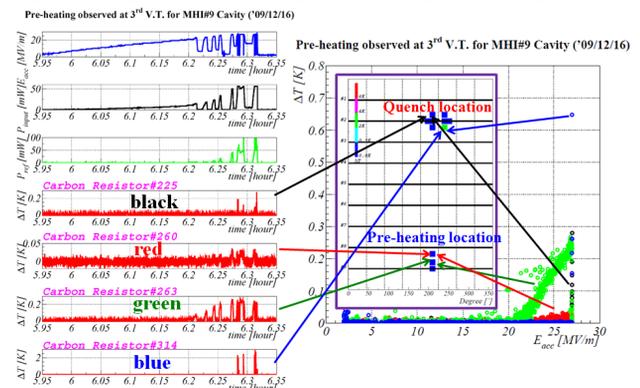


Figure 3: The pre-heating observed at 3rd V.T. for MHI#9.

Comparison of Radiation Level Between Top and Bottom Direction Using PIN Diodes

Figure 4 shows the comparison of the output from PIN diodes between the top and bottom direction of a cavity in

every vertical test. Three PIN diodes for each direction are attached on the cavity axis. In many cases, it is found that the radiation level at the top direction is higher. This may mean that some contamination or particulate fall down from the top to the bottom direction of a cavity during the assembly working in the clean room. It is conceivable that the main cause of the heavy field emission in STF is such contamination or brown stains [3].

cavity	# of V.T.	Gradient [MV/m]	Radiation level [μSv/h]	P.D. (Top) [V]	P.D. (Bottom) [V]	larger direction
MHI#5	1 st	27.3	>999	>>10	>10	top
MHI#5	2 nd	19.7	134	5	1	top
MHI#5	3 rd	27.1	303	0	0	—
MHI#6	1 st	25.7	>999	>10	8	top
MHI#6	4 th	19.6	0	0	0	—
MHI#6	6 th	27.7	>99900	13	0	top
MHI#7	1 st	16.5	4120	4	10	bottom
MHI#7	2 nd	33.6	>99900	>14	1	top
MHI#8	1 st	16.0	256	0	0.5	bottom
MHI#8	2 nd	26.8	1410	0	5	bottom
MHI#8	3 rd	17.5	0	0	0	—
MHI#8	4 th	37.8	>99900	>14	3	top
MHI#9	1 st	25.0	>99900	>10	10	top
MHI#9	2 nd	15.9	1360	0.5	0	top
MHI#9	3 rd	27.0	>99900	>14	0	top

Figure 4: The comparison of the output level from PIN diodes (P.D.) between the top and bottom direction. Radiation level is the value measured by the radiation monitor at the top flange of the cryostat.

DEVELOPMENT OF ONLINE MONITOR

For the convenience in the offline data analysis and the improvement of the online monitor, the new online monitor system was introduced using EPICS and Java script in the recent several tests. EPICS is the useful tool for the data record and Java is the strong language for the online monitor with the fast response including T-mapping and X-ray-mapping, which is updated every 5 seconds.

Figure 5 shows the present online monitor in STF. The left figure shows the T-mapping and X-ray-mapping, which is the online display at the pre-heating observed in the third vertical test for MHI#9, and the right one shows the time trend of RF outputs and PIN diodes. From the right figure, it is clear that there is the correlation between the heating at cell #9 and the x-ray emission.

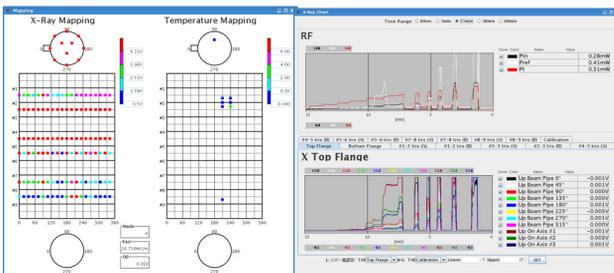


Figure 5: The online monitor using EPICS and Java.

SUMMARY

The T-mapping system identified perfectly the heating location at the quench during the vertical tests for S1-Global project in STF. Figure 6 shows the summary of the heating cell for every vertical test. There is no excess bias in the heating cell. The main cause is the thermal quench due to defect or contamination. However, in many cases, any target was not observed around the heating location. This is the most common case in STF.

The new online monitor system using EPICS and Java was introduced in recent several tests. It is easy to identify the heating location by the online T-mapping display.

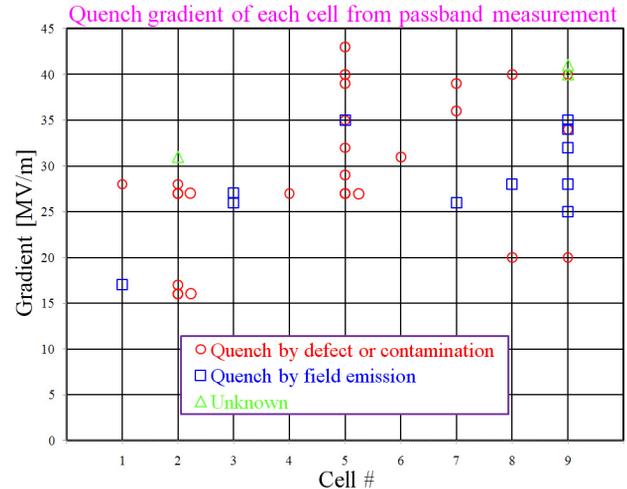


Figure 6: The summary of the heating cell and the limit cause for every vertical test.

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REFERENCES

- [1] Y. Yamamoto, et al., “A new cavity diagnostic system for the vertical test of 1.3GHz superconducting 9-cell cavities at KEK-STF”, PAC’09, Vancouver, Canada, (2009), TU5PFP076.
- [2] Y. Yamamoto, et al., “Cavity diagnostic system for the vertical test of the baseline SC cavity in KEK-STF”, SRF’07, Beijing, China, (2007), WEP13.
- [3] T. Saeki, et al., TTC meeting 2010, FNAL, U.S. “<http://indico.fnal.gov/conferenceDisplay.py?confId=3000>”