# THE ECT SYSTEM FOR RAON'S CAVITIES

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*Abstract*

The ECT system is in use for Nb surface control in many laboratories. This system can inspect Nb surface quickly using high resolution. The ECT system for RAON's cavity was made with the feature : It has 3-axis acting probe movement system, It can inspect big size of Nb sheet, which is 1m by 1m and It contain the analysis program that can show the result as 2D and 3D image as well as relative figure of surface level. The standard sample was made with various sizes of defects using the same Nb sheet that was used to make RISP cavity. The ECT system conditioning was carried out to optimize ECT operation on the frequency, the range is from 300kHz to 2MHz. The result of 900 kHz shows the strongest signal. The conditioning experiment on other parameter will be carried out in near future.

## INTRODUCTION

It is very important to make high performance cavity in SRF cavity field in terms of reducing the cost as well as getting high quality beam. The quality control is necessary to make high performance cavity. There are three aspects in terms of quality control: purity, workability, and surface quality [1]. Because of this reason, many non-destructive tests were used for SRF cavity fabrication. The ECT system is one of the non-destructive inspection methods and it has been used to control surface quality of Nb in many accelerator laboratories such like FNAL, DESY and KEK [2-9]. The ECT system is for finding out surface defect such as pit, scratch, voids and cracks. It can also detect foreign material like Ta, Fe and so on. The ECT system has some advantages compared with other non-destructive inspection systems. These are: it is fast, has high resolution and easy to operate.

### *RISP Cavity*

The goal of RISP (Rare Isotope Science Project) is to make the accelerator which can generate the 200 MeV/m beam energy based on uranium beam [10]. A total of over 550 cavities are needed to make the linac part of the RISP accelerator which was named RAON. We will use four kinds of cavities to meet the beam quality of RAON [11] and each cavity needs 3~4 Nb sheets that has the size of 1200 by 635mm. Nb sheets have similar properties with other SRF cavity material. The RRR value is larger than 300 and average grain size of Nb is finer than 64μm [12].

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Figure 1: Four types of SRF cavities used for RAON superconducting linac [11].

## RISP ECT SYSTEM

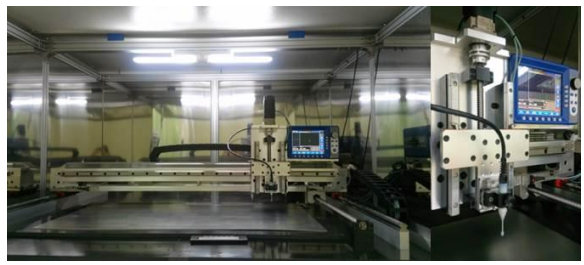


Figure 2: The ECT system for RAON's cavities.

Figure 2 shows the ECT system for RAON's cavities. It has the features as follows,

- The probe moves by 3-axis machinery system: It is more accurate than using turntable to find out the position of defect.
- The RISP ECT system can inspect about 1m by 1m large sheet.
- The probe was customized product by ZETEC, Inc.
- The ECT main body was also made by ZETEC, Inc.
- The analysis program made by FORUTEC, which is one of the domestic company in South Korea, can show the 2D and 3D result including relative surface level of the sample.

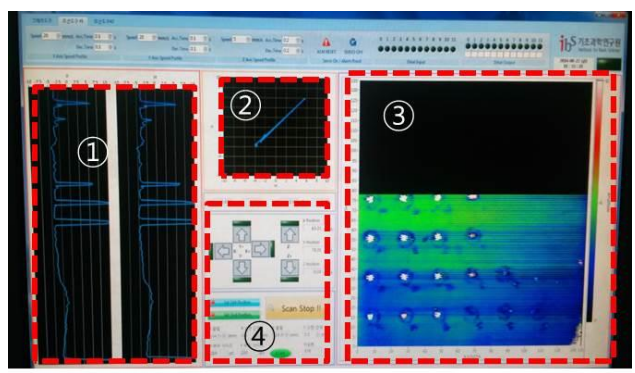



Figure 3: RISP ECT analysis program.

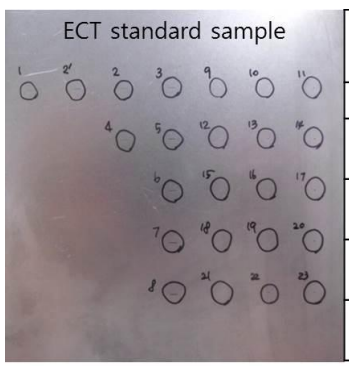


ISBN 978-3-95450-142-7

① The original signal of X-axis and Y-axis from ECT machine.
② Lissajous' pattern which was made by XY-axis original signal.
③ The 2D image of sample. The color indicates relative surface level.
④ This part is for controlling of ECT probe movement system.

### *Standard Sample*

Basically, ECT system needs the standard sample to analyze the result by comparing the signal from sample with the signal from standard sample. Because of that the signal change according to the subject material, defect size and kind, the frequency. So typical signal and Lissajous pattern are necessary to analyze the result from sample. The EDM (Electric-discharge machining) method was used to make standard sample. Figure 4 shows the built standard sample with the EDM electrode diameter and feasible depth. Since pure Nb is not commercial material, material properties data for SRF cavity are insufficient. Number one defect in the standard sample was planned 50μm in diameter and 50μm in depth. Defects size was planned by gradually increasing in size number until 23 defect, which have 500μm diameter and 500μm depth.




| Aim diameter (mm) | EDM electrode diameter | Feasible depth |
|---|---|---|
| 0.05 | 0.035 | 0.05 |
| 0.1 | 0.08 | 0.01 ~0.2 |
| 0.2 | 0.15 | 0.01 ~0.5 |
| 0.3 | 0.27 | 0.01 ~0.5 |
| 0.5 | 0.45 | 0.01 ~0.5 |

Figure 4: Standard sample and EDM electrode data.

The standard sample was tested by KTL (Korea Testing Laboratory) using non-contact 3-D measurement, with VIEW Benchmark™250 made by VIEW, Inc. Figure 5 shows the test results. It wasn't made as original plan due to the lack of EDM data and skill to handle pure Nb. However since it has a variety of defect sizes, it is enough to do conditioning of ECT system.

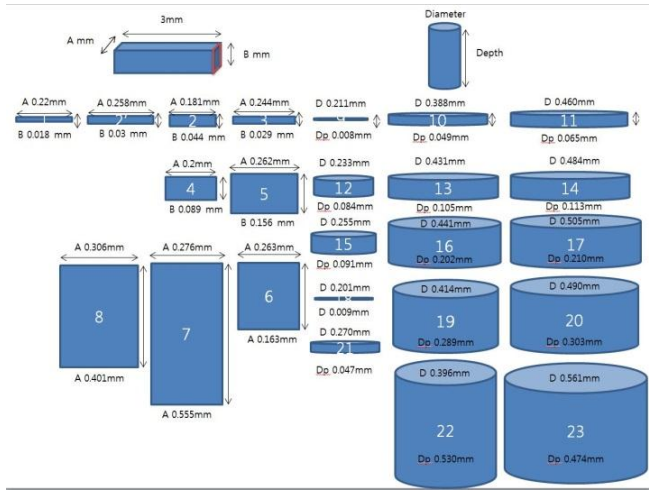



Figure 5. The result of KTL test.

### *ECT System Conditioning*

The conditioning needs to set up the best operation condition. It should be carried out on the frequency, speeding, spacing during probe movement and lift-off which will be carried out by the z-axis. The frequency experiment was carried out at the range of 300kHz to 2MHz so far. Each scanned signal was recorded as the relative figure and that can represent the relative surface level of the sample, which is standard sample in this case. Figure 6 shows the raw data of one of the frequency experiment results. The result was painted gradually increased in red color. The higher the number, the darker the red. The green bar also indicate the number size of result. The circle in the middle of the Figure 6 is one of the defects of standard sample.

Figure 6: Relative number of surface level.

The frequency experiment results of 300kHz, 500kHz, 700kHz, 900kHz, 1MHz, 1.3MHz and 2MHz are shown in Figure 7. The case of 900kHz , as shown in the Figure 7, has the strongest signal and 300kHz and 2MHz are shown to have faintest signal, specially, the result of 2MHz has the weakest signal.




ISBN 978-3-95450-142-7

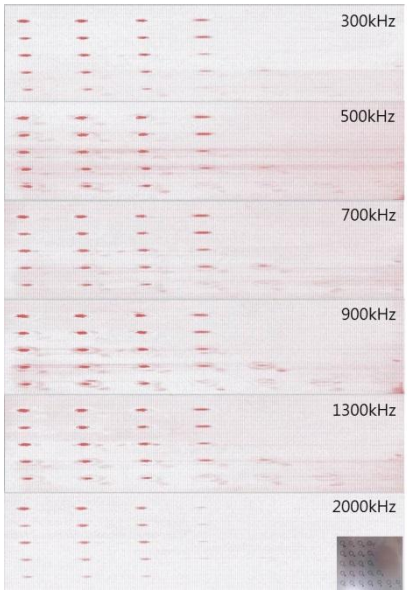



Figure 7: Measured by frequency change.

Results also were analyzed as 3D image. Figure 8 shows the result of frequency experiment as the 3D image between 300kHz and 2MHz. It is obvious that the result of 900kHz shows the strongest signal in the 3D image result. It was carried out between 750kHz and 950kHz at intervals of 50kHz but the results were same in this range. Thus we will adopt the frequency of 900kHz for RISP's ECT system.

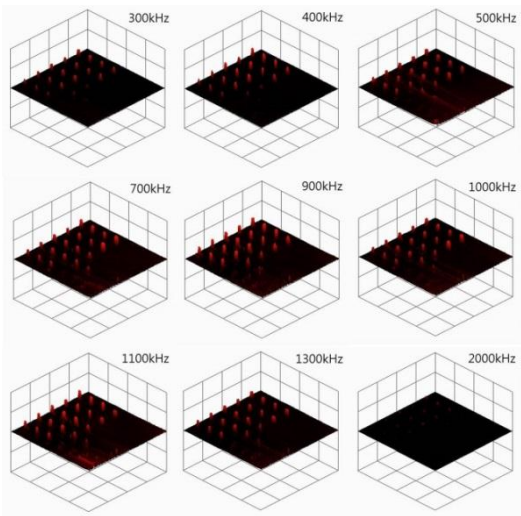



Figure 8: 3D images of frequency change.

### *Further Work*

More conditioning experiment will be carried out on speeding and spacing of probe and lift-off effect. Since the result of ECT shows the relative figure of surface level, it will study that correlation between real defect size and relative figure. Defect size study will be carried out with the further research of non-destructive test of SRF cavity to set up the criteria for acceptable defect size.

## CONCLUSION

The ECT system for RAON's cavities was established. It was made by domestic company in South Korea with ZETEC's ECT products. It has 3 axis-acting probe machinery system to get more accurate information of defect position. It also has analysis program that can show the 2D and 3D image result and relative figure of surface level. ECT experiment was carried out on the frequency between 300kHz and 2MHz. The result of 900kHz shows the strongest signal. Thus we adopt this frequency to operate RISP ECT system. The experiment on other parameter will be carried out in the near future with defect study.

## ACKNOWLEDGMENT

This work was supported by the Rare Isotope Science Project of Institute for Basic Science funded by the Ministry of Science, ICT and Future Planning (MSIP) and the National Research Foundation (NRF) of the Republic of Korea under Contract 2013M7A1A1075764.

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