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EFFECT OF N_2 GAS EXPOSURE ON THE L-BAND SUPERCONDUCTING CAVITY

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Abstract

We conducted highly sensitive measurements on the effect of exposing a superconducting cavity to nitrogen gas. As a reference, the cavity was first measured before exposure. Then measurements were made after exposing the cavity to nitrogen gas for totally 3 days. No remarkable degradation were observed in those measurements. We will continue this experiment for longer exposure term.

1 INTRODUCTION

It is reported that some degradation of the performance has been observed in horizontal assembly after vertical measurements in TRISTAN superconducting cavities [1]. There are some questions about the cause of this degradation. To prevent the degradation before installing the cavities into a beam line, it is necessary to find out the causes and make some improvements.

As a cause of the degradation, the effect of nitrogen gas on the surface of Nb cavity is suspected. Nitrogen gas is often used to break the cavity vacuum after the vertical measurements to prepare for horizontal assembly.

We conducted highly sensitive measurements to see the effect on nitrogen gas exposure.

2 RESEARCH OF THE EFFECT OF NITROGEN GAS ON CAVITY PERFORMANCE BY VERTICAL MEASUREMENT

In this experiment, nitrogen gas exposure period was increased by one day, totally up to for 3 days. The high purity nitrogen gas from a cold evaporator was used for this experiment. In the vertical measurements, temperature dependence of surface resistance Rs was carefully measured from 4.25K to 1.5K. And the residual surface resistance R_{res} was evaluated by fitting the data with the following equation,

$$R_s=(A/T)\exp(-D/kT)+R_{res} \quad (1)$$

Then, an Q_0 vs. E_{acc} curve was measured at the lowest temperature. Prior to exposing the cavity to nitrogen gas, a vertical measurement was performed to confirm the baseline performance: Q_0_10^{10}, E_{acc}_30MV/m, and no field emission. Then the cavity was warmed up and connected to a vacuum system shown in Figure 1. Subsequently, nitrogen gas was introduced into the cavity through a filter with 0.01μm mesh and the valve was closed for the exposing period.

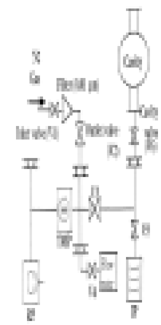

Figure 1: Nitrogen venting system

3 PROCEDURE OF INTRODUCING NITROGEN GAS INTO THE CAVITY

Nitrogen gas was introduced into the cavity by the procedure as follows.

1) Adjustment of the nitrogen gas flow rate prior to the venting

After fully opening the valves V1 and V4, nitrogen gas was vented and the flow rate was adjusted by the valve 2 at 900cc/min monitoring with the flow meter. It had already been confirmed that this flow rate makes no influence on the cavity performance [2]. The valve V2 was not handled after that not to contaminate the system by valve operations.

2) Prebaking of the vacuum system prior to opening the cavity

After the valves V1 and V4 were closed, the system was evacuated to the pressure of around 1×10^{-5} Torr by a set of a rotary pump and a turbo molecular pump with baking. In this process, the valve V6 remained closed and the cavity was not evacuated.

3) Vacuum connection of cavity and vacuum system

We know experimentally that the pressure in the cavity is around 5×10^{-5} Torr after the cold measurement. So the

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valve V6 was opened carefully when the pressure of the system reached to $1x10^{-5}$ Torr.

4) Venting the nitrogen gas into the cavity

After switching off the turbo molecular pump, the valve V1 was fully opened while the turbo molecular pump was still moving so that the contaminants did not reach into the cavity with turbulent gas flow. After that, the rotary pump was switched off. It takes ten minutes to fill up the cavity. Then the valve V6 was closed.

5) Evacuation of the cavity for preparation of vertical measurement

After exposing the cavity to nitrogen gas for a predetermined period, the cavity is evacuated by the rotary pump, the turbo molecular pump, and the ion pump with baking at 85_ for one night. At the pressure around $1x10^{-9}$ Torr, the valve V6 was closed. Subsequently, the cavity was installed in the vertical cryostat and its performance was measured.

4 RESULTS OF THE MEASUREMENTS

Figure 2 shows the Q_0 vs. E_{acc} curves of the cavity which is exposed to nitrogen gas for up to a total of 3 days. Figure 3 shows the dependence of surface resistance on temperature. As a result, no remarkable differences were found compared to the reference data.

Figure 4 shows the relation between duration of nitrogen exposure, $E_{acc,max}$, A, D/k, and residual surface resistance R_{res}. A, and D/k is derived by fitting the equation (1) to thermal dependence curve of surface resistance R_s. No significant changes are found in each parameter.

Figure 5 shows the amount of x-ray during the vertical measurements. The graphs on the left side shows processing levels at the first measurement. Multipacting levels are observed at 17MV/m-24MV/m and at 28MV/m-32MV/m. On the other hand, the graphs on the right side show the processing levels in the measurements after RF processing. From this figure, there seems to be a tendency that the lower multipacting level disappears after the RF processing, but the higher multipacting level cannot be eliminated by the RF processing. The lower multipacting level reappears after the cavity is exposed to nitrogen gas, but it can be removed again by RF processing. This multipacting may be caused by nitrogen exposure effect or the contaminants flowed into the cavity when the nitrogen gas was introduced or the adsorption of residual gas in the cavity, however it is not obvious in this stage. But remarkable degradation is not observed in the cavity performance within the exposure term of 3 days.

5 CONCLUSIONS

Highly sensitive measurements were conducted on the effect of exposing a superconducting cavity to nitrogen gas for totally 3 days. As a result, no remarkable degradation was observed in the cavity characteristics.

We will continue this experiment for longer exposure.

6 ACKNOWLEDGMENTS

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7 REFERENCES

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[2] K.Saito et. al., "Basic Study on The Horizontal Assembly of SC-Pair Cavities into Cryomodule",Proc.of 1st Superconducting Linear Acc Meeting in Japan, KEK, Japan, 1998

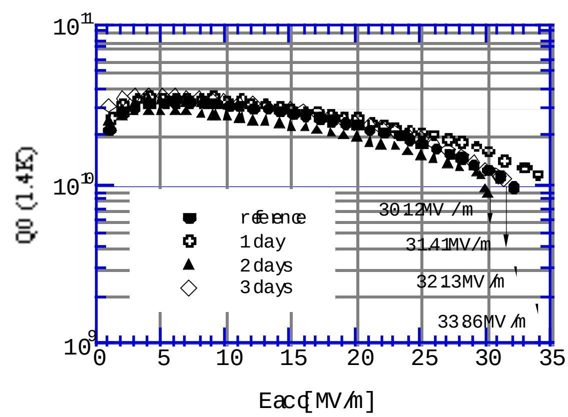

Figure 2: Nitrogen effect on Q_0 vs. E_{acc} curve

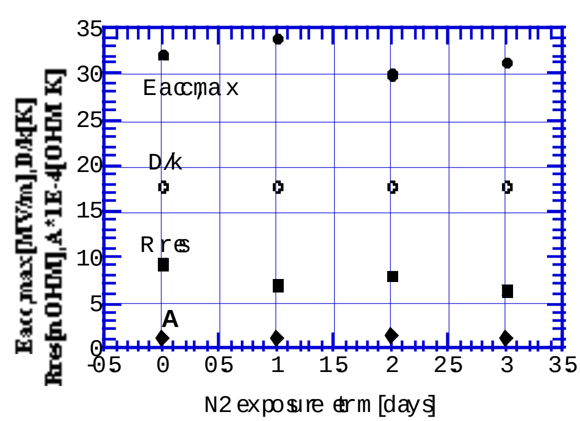

Figure 3: Nitrogen exposure effect on R_s vs. 1/T curve

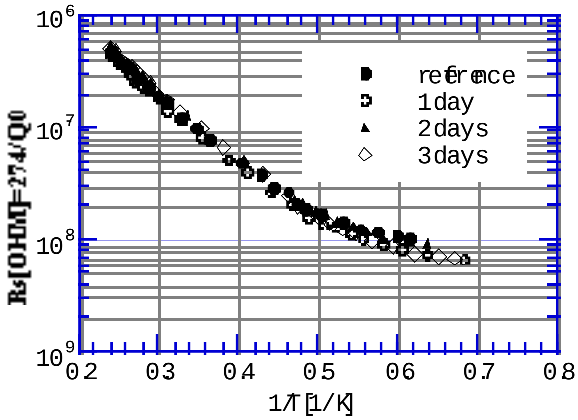

Figure 4: Nitrogen exposure effect on $E_{acc,max}$, A, D/k and R_{res}

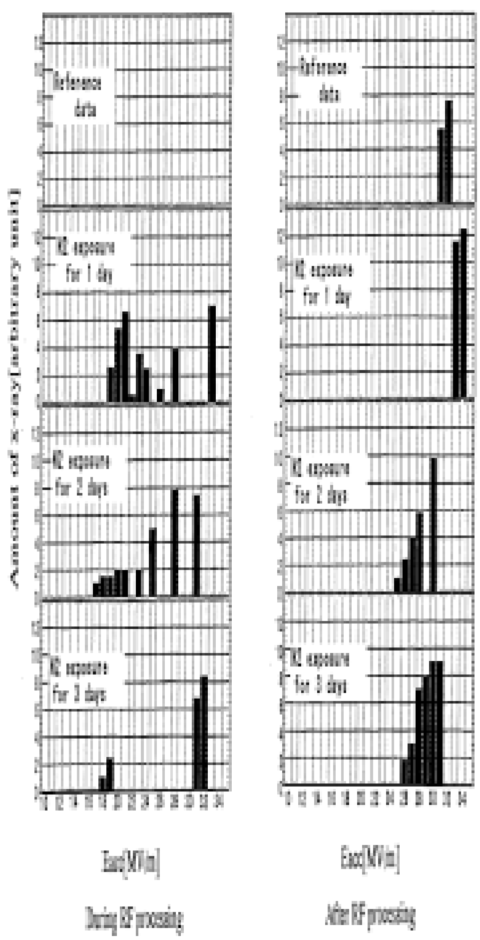

Figure 5: Occurrence of x-ray