

TM-FURNACE QUALIFICATION AT CORNELL

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Abstract

New TM vacuum furnace had been installed to Newman laboratory at Cornell. The furnace is routinely used for annealing, degassing, and high- and low-temperature bake of Nb SRF cavities and samples. We will describe our qualification study on our new furnace.

INTRODUCTION

To process Cornell ERL 7-cell cavities, we have installed TM vacuum furnace in our SRF facility. Furnace could be available up to 1450 °C, achievable highest vacuum is 1.0e-8 Torr, and specified dimensions are 24 x 24 x 60 cubic inch. Figure 1 shows images of TM vacuum furnace. Major usage of furnace will be hydrogen degassing and low temperature bake of 7-cell cavities.

Our original hydrogen degassing parameter is 650 °C x 10 hrs. The 1st ERL 7-cell cavity, ERL7-1, had been

degassed with that parameter at Jlab before installation of TM furnace in our facility. ERL7-1 successfully achieved our specifications at vertical test [1] and then installed to horizontal test cryomodule. As qualification of furnace and optimization of degassing parameter, we have done systematic bake tests followed by vertical tests on single cell cavities.

TEST BAKE ON SINGLE CELL

We had prepared two single cell cavities, cavity #1 and #2, that highly contaminated with hydrogen by centrifugal barrel polishing (CBP). After CBP, cavities were processed by 10 microns of buffered chemical polishing (BCP) followed by ultra-sonic cleaning (USC) and high pressure rinsing (HPR). Cavity #1 was baked in TM furnace from 650 °C to 1000 °C. We have kept 650 °C until partial pressure of hydrogen went down and got saturation. After saturation, increase temperature to 800, 900, and 1000 °C and kept each temperature until pressure saturation. Figure 2 shows results of test bake on cavity #1. X axis shows time in hours and Y axis shows partial pressure in Torr. It took about 4 days to get saturation of hydrogen at 650 °C. When we increased temperature to 800 °C, additional hydrogen came out; above 800 °C no additional hydrogen was released. These results suggest that 650 °C could not release all hydrogen absorbed in bulk Nb.

CURE HYDROGEN Q-DISEASE

Cavity #2 was kept 100 K over night, and then tested to confirm hydrogen Q-disease before furnace bake. Figure 3 shows the result. Cavity was limited by RF power at 10 MV/m with low Q_o of 1e8, Q-disease was confirmed. Cavity #2 was baked 2 days at 850 °C in TM furnace. Figure 4 shows 850 °C bake log of cavity #2 in TM furnace. After furnace bake, cavity was processed by USC and HPR, but no chemistry. 1st VT was done with fast cool down. After warming up cavity to room temperature, 2nd VT was done with slow cool down (kept cavity 100 K over night). These results are also shown in Figure 3. Cavity was limited by RF power again, but Eacc was improved to 28 MV/m with Q_o of 1e9; Q-disease had been successfully cured by furnace bake.

Based on single cell test bakes and VT results, 850 °C bake seems more promising to hydrogen degassing and cure hydrogen Q-disease. In parallel with cavity test bake, Nb sample was baked in TM furnace. Nb material had started to become slightly soft more than 800 °C bake, so we decided to not go higher temperature than 800 °C, and also decided to bake ERL 7-cells cavity 4 days at 650 °C.

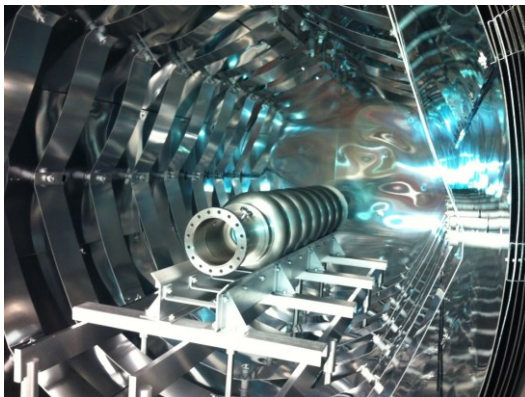


Figure 1: un-stiffened (top) and stiffened (bottom) Cornell ERL 7-cell cavity.

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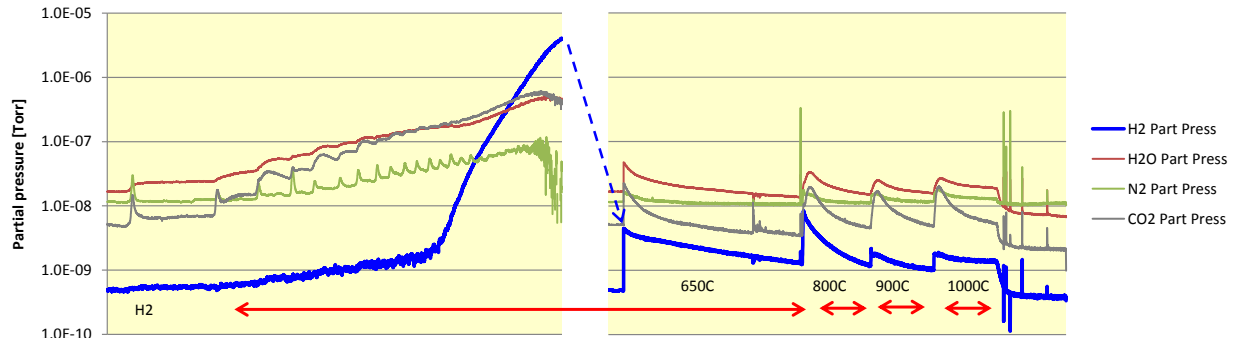


Figure 2: Test bake on single cell highly contaminated with hydrogen.

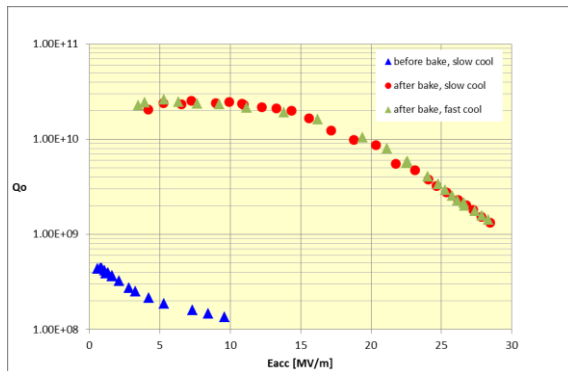


Figure 3: cure of hydrogen Q-disease.

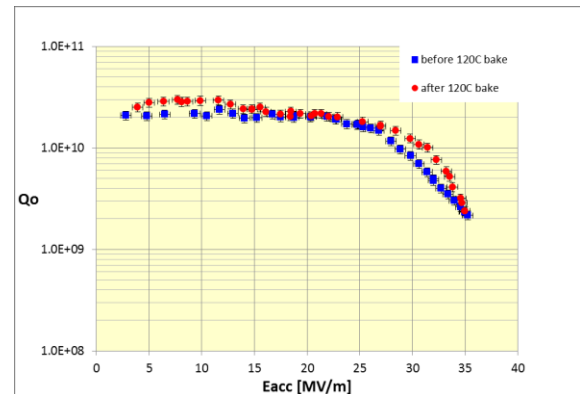


Figure 5: VT results of single cell before and after 120C bake in TM furnace.

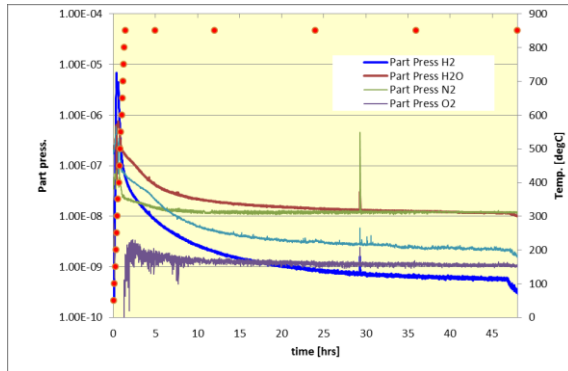


Figure 4: Furnace degassing log of cavity #2.

LOW TEMPERATURE BAKE

We had also planned to use TM furnace for low temperature bake (120 °C x 48 hrs). After confirming no hydrogen Q-disease, Cavity #2 was processed with 10 microns of BCP followed by USC and HPR. Cavity #2 was tested twice before and after 120 °C bake in TM furnace; Figure 5 shows the results. Eacc was improved up to 35 MV/m with Qo of 2e9 by additional BCP, limitation was RF power. After 120 °C bake, cavity performance was almost same and no degradation was observed by 120 °C bake in TM furnace. So we concluded furnace was clean and available for low temperature bake at 120 °C.

ERL7-CELL BAKE IN TM FURNACE

ERL7-2 was processed by bulk BCP (140 microns), hydrogen degassing in TM furnace (650 °C, 4 days), light BCP (10 microns), low temperature bake (120 °C, 48 hrs), and HF rinse. Chemistries were followed by USC and HPR. Figure 6 shows degassing log of ERL7-2 in TM furnace. ERL7-2 had been measured twice, 1st VT was done with fast cool, 2nd VT was done with slow cool (kept cavity 100 K over night). Figure 7 shows results. Cavity had achieved 13 MV/m with high Qo of 2e10 at 1.8 K at 1st VT, but limited by RF cable trouble. After fixing RF cable issues, 2nd VT with slow cool shows same high Qo of 2e10 at low field and achieved 21 MV/m with Qo of 1.47e10; no hydrogen Q-disease was observed.

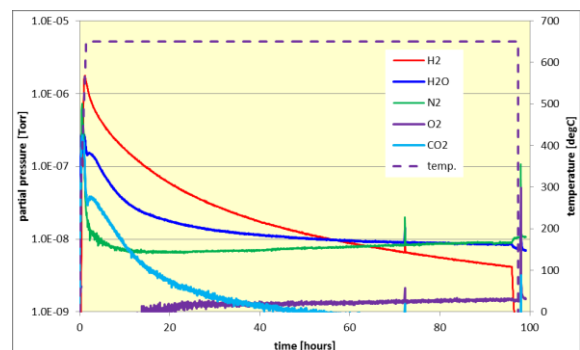


Figure 6: degassing log of ERL7-2.

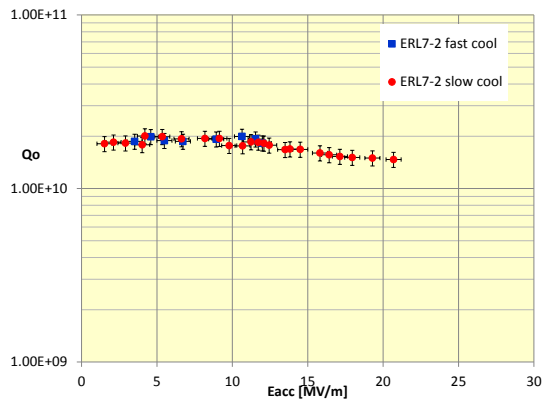


Figure 7: VT results of ERL7-2 at 1.8K

SUMMARY

Qualifications on TM furnace have been done. ERL7-cells had been processed in TM furnace routinely and achieved our specification values. No performance degradation, no hydrogen Q-disease happens by furnace bake. Of course hydrogen Q-disease could be cured by high temperature bake in TM furnace. More R&D on optimization of degassing parameter is planned.

REFERENCES

- [1] F. Furuta et al., in these proceedings, TUP048.