Report of vertical test of the β=0.12 half wave resonator (HWR) at RISP

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Abstract

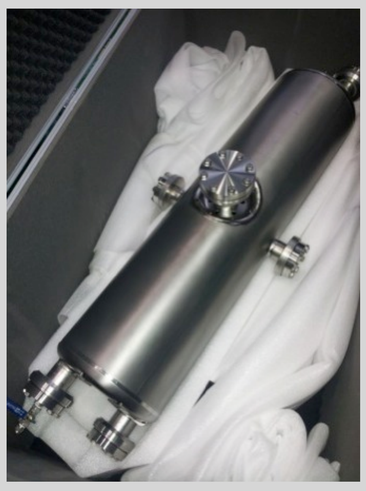
We report on the first vertical test of the f=162.5 MHz, β=0.12 half wave resonator (HWR) developed at Rare Isotope Science Project (RISP). After the fabrication of the first prototype by the vendor Vitzrotech, the cavity was sent to TRIUMF, Canada for surface processing and the vertical test.

At TRIUMF, the cavity was given a standard surface processing combined with low temp. baking. The cavity acheived its target, reaching Q_0=1e9 at E_{acc}=6.3 MV/m limited by field emission. Other characteristics of the cavity such as helium pressure sensitivity, Lorentz force detuning (LFD), and residual resistance were also studied.

Introduction

- The HWR was designed to accelerate the uranium beam from 2.5 MeV/u to 18.5 MeV/u in RAON, a proposed driver linac of the RISP.
- The cavity was fabricated by Vitzro tech and was sent to TRIUMF for surface processing and vertical test.

The completed HWR



The specification of the HWR

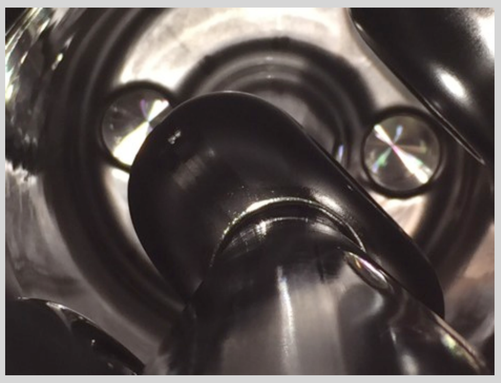
Figures of merit	Unit	Value
f	MHz	162.5
β_{opt}	-	0.12
V_{acc}	MV/m	1.3
Q_0	-	4.20E+09
E_{peak}	MV/m	35
B_{peak}	mT	58
T	K	2

Surface processing and test preparation

- The HWR was given buffered chemical polishing (BCP) using acid mixture

$HF : HNO_3 : H_3PO_4 = 1:1:2$ (volume ratio)

The etching was done to remove 120μm with the temperature kept between 10C to 14C.



- The cavity was rinsed with high purity water at high pressure (HPR) to get rid of the field emitter.

The rinsing was done at water pressure 600psi for 7 hours in total. The cavity was left to dry in class 10 clean room over 48 hours.

- For the second cool down, low temperature baking at 120C was done for 48 hours. The vacuum was in 1e-6 torr range.
- Before the cool down, the cavity was assembled in class 10 clean room followed by the leak check.

Vertical test

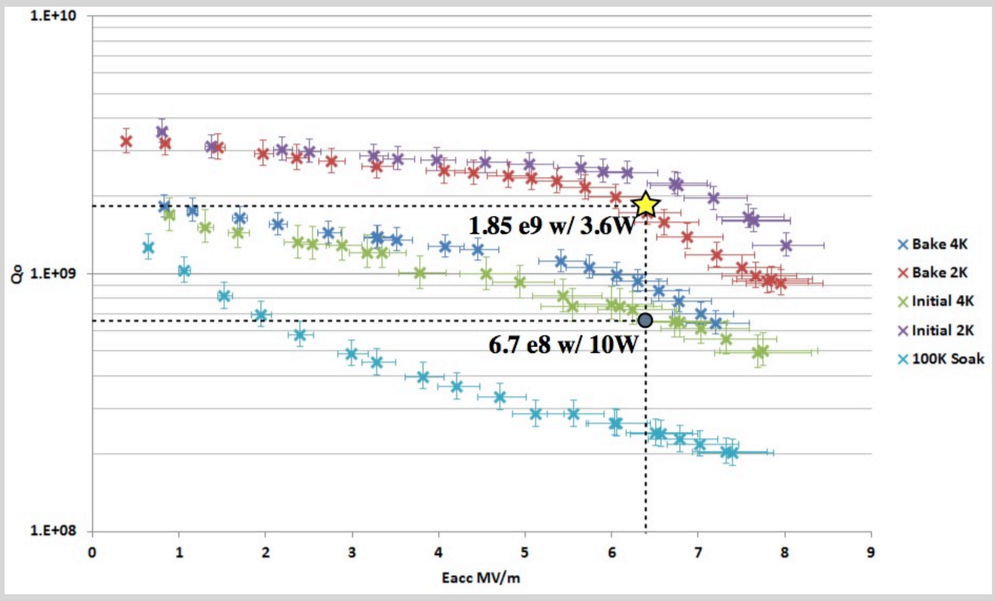
- The cavity was cooled down to cryogenic temperature 4 times:

1. After the standard processing, combination of BCP and HPR, the cavity was cooled down to 4K and 2K. At 2K, the cavity reached Q_0=2.2e9 at E_{acc}=6.3 MV/m. The performance was limited by strong field emission at E_{acc}=8 MV/m.

2. Low temp. baking was done before cool down to 4K and 2K. In spite of moderate improvement at 4K, Q_0 value was degraded a little at 2K. Similar phenomenon was observed in QWR vertical test.

3. The cavity was warmed up to parking zone and kept in the zone over 9 hours to check if there are hydrogen left over from BCP. The result shows the significant remains of the hydrides.

4. To push up the limitation by field emission, additional etching by 20 μm was done before cool down and HF rinse is applied before cool down without too much change in the performance.

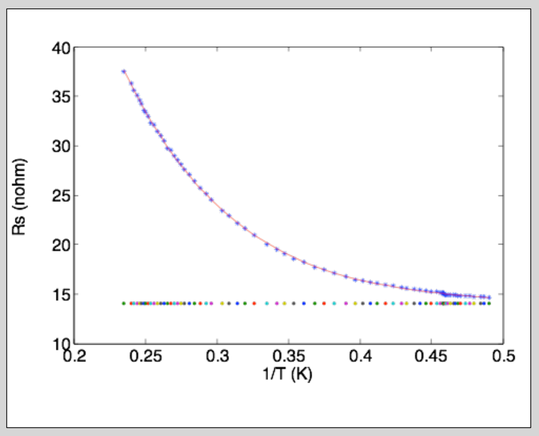


The excitation curve : Q_0 vs. E_{acc}

- Multipaction barriers were met at 30-60 kV/m, 80 kV/m, 160 kV/m and 3.6 to 5.6 MV/m. In the first cool down, the barriers were processed away within 1 hour. Low temp. bake made the multipaction even worose.

- Helum pressure sensitivity, Residual resistance, Lorentz force detuning (LFD) were measured in cool down from 4K to 2K.

The surface resistance vs. 1/T



The measurements in 2K

	Before bake	After bake
R_{res}	14.19 nΩ	16.85 nΩ
R_{BCS}	0.5 nΩ	0.11 nΩ
df/dp	-10.8 Hz/torr	-
K(LFD)	-7.5 Hz/(MV/m)^2	-

Summary

- Surface processing of the HWR was done successfully, while leaving the possibility for high temperature annealing to get rid of remnan hydrogen.
- Vertical test to 4K and 2K was successfully done. The cavity met its target Q_0=1e9 at E_{acc}=6.3 MV/m.
- We believe more options for surface processing to push up the limitation even further.

Acknowledgments

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