SRF CAVITIES FOR RAON

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Abstract

SRF cavities of superconducting linear accelerators in RAON are developed and tested at 2K/4K. 1st Quarter Wave Resonator (QWR) and Half Wave Resonator (HWR) are fabricated by a domestic vender and tested in the TRIUMF's facility. The measured Q factors are above the required values at the operating gradients. And the predicted multipacting phenomena are observed in the test and easily conditioned. The Q factors decreased after a slow cooldown and enhanced at 4K tests by a low temperature baking. Based on these tests, modified bare cavities are newly developed, jacketed and will be tested with tuners and power couplers.

INTRODUCTION

Four different types of TEM-like superconducting cavities are adopted for RAON, the facility for Rare Isotope Science Project (RISP) [1, 2]. The 1st prototypes of Quarter Wave Resonators (QWRs) [3], Half Wave Resonators (HWRs) [4], and Single Spoke Resonators (SSRs) [5] were designed and fabricated. A QWR bare cavity and a HWR bare cavity were formed and assembled using 3mm thick RRR300 Niobium sheet and tubes by VITZRO tech., Korea. SSR cavities were manufactured by SFA, Korea. After fabrication, the QWR, HWR cavities were buffered chemical polished (BCP), cleaned, and tested in TRIUMF, Canada. The SSR type II cavity is on the post processing and will be tested in the RAON SRF test facility. The QWR and HWR cavities will be jacketed, assembled with tuners and RF couplers, installed in cryomodules within this year. The 2nd prototypes of QWRs, HWRs are being fabricated by RI, Germany and two 2nd prototypes of SSR type I cavities are being developed with TRIUMF and PAVAC, Canada.

FABRICATION

Curved parts of QWRs, HWRs are formed using a 200 ton pressing machine and the stainless flanges are attached to seamless pipes by Cu alloy brazing. Fabricated parts are assembled by the electron beam welding in the condition of less than 5×10^{-6} torr vacuum level. All surfaces which are welded are prepared by the light BCP, ultra-sonic cleaning, and etc. Fabricated parts of QWRs are shown in Figure 1. The upper end, the beam port cups of QWR and both end of HWR are stiffened with reactor grade Niobium ribs, and the beam cups of HWR are stiffened by additional curvatures, the doublers. There are four ports for high pressure rinsing in the ends of QWR, HWR cavities and the both ends are welded to the outer cylinders. To adjust the resonant frequency of cavities, beam ports are squeezed by mechanical tuners. The fabricated 1st QWR and HWR cavities are shown in the Figure 2.

Figure 1: Formed parts of QWR cavities.

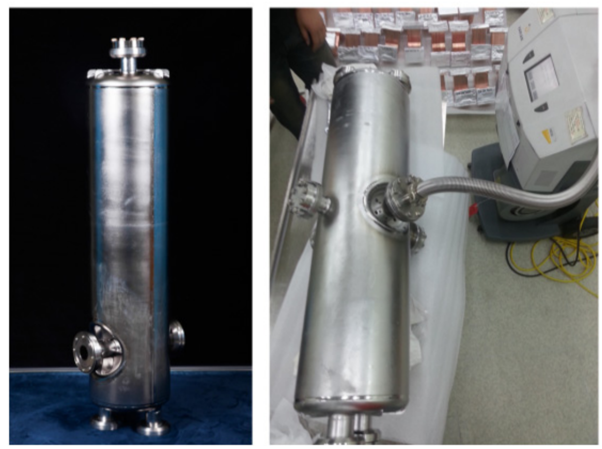

Figure 2: 1st QWR bare cavity (left), Leak test of the 1st HWR bare cavity (right).

PERFORMANCE TEST

The main purposes of 1st prototyping of SRF cavities are to achieve the required Q factor and the accelerating gradient. And also the frequency shift during processing and testing are important to modify the design off cavities. To measure the performances of cavities, 1st QWR and HWR are sent to TRIUMF, 120um etched, high pressure rinsed and assembled with test stands in the TRIUMF test facility. The Q factors at 4K and 2K are measured and the frequency fluctuation, Lorentz detuning are also measured.

Q Factor Measurement

QWR cavities in RAON will be operated at about 4K. The required Q factor is above 2.4×10^{8} when the accelerating gradient is 6.6MV/m (35MV/m peak E-field); the estimated peak electric field is 35MV/m. QWR cavity is tested after 120µm etching, after 120°C 48hours baking, after additional 15µm light BCP as shown in Figure 3. The measured Q factor at the operating point is about 1.3×10^{9} which is 2.3 times higher than the requirement. The achieved highest accelerating voltage, peak electric

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field, peak magnetic field is 2.3MV, 72MV/m, and 128mT separately after the 120 degree baking and the 15um light etching.

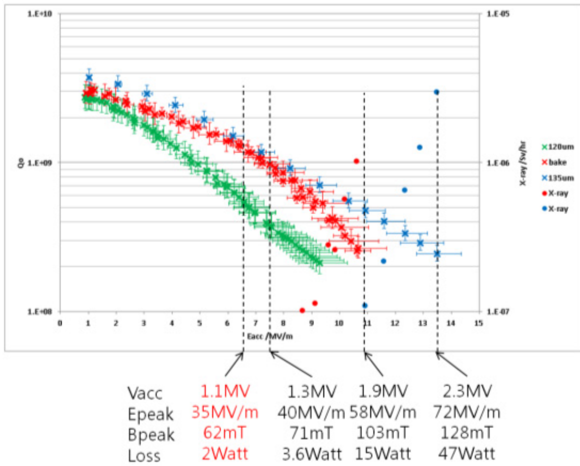

Figure 3: Q factor verse Eacc of QWR at 4K test.

The Q factor of this QWR at 2K is about 1×10^{10} and the residual resistance is 2.5nΩ, the BCS resistance is 4.7nΩ at 0.9MV/m gradient.

The required Q factor of HWR at 2K is about 2.1×10^{9} at 6MV/m the accelerating gradient. The measured Q factor is about 2.5×10^{9} and the residual resistance is 14.2 nΩ and BCS is 0.5nΩ at 4 MV/m.

Multipaction

The Multipacting band of QWR is checked during Q factor test. The measured band is compared with the predicted by MultiP-M code [6] and CST code [7] as shown in Table 1.

Table 1: Multipacting Band of QWR (Accelerating gradient, MV/m)

Measured	MultiP-M	CST
1.1-1.3	0.22-1.5	0.37-1.12
	0.066-0.12	0.74-0.22
0.023-0.13	0.013-0.062	0.011-0.068
	0.002	0.007-0.037

Mechanical Properties

The changes of the resonant frequencies of QWR and HWR bare cavities are measured during the BCP process and cryogenic RF test. The measured values are similar with the predicted values using the Multiphysics code, CST and ANSYS. But the predicted value of df/dp is -16.8Hz/mbar with 3mm uniform thick model, about the half of -32.6Hz/mbar as shown in the Table 2. This difference should mainly depend on the decrease of the thickness of the cavity after the deep drawing and the BCP process.

Table 2: Measured Properties of 1st QWR and HWR

Parameters	QWR	HWR
Etching rate (kHz/um)	+0.78	+0.66
Frequency shift during cooldown (kHz)	+148	+290
Frequency shift vs. external pressure (Hz/mbar)	-32.6	-8.1
Lorentz detuning $(Hz/(MV/m)^2)$	-19.8	-7.5

CONCLUSION

The 1st SRF cavities are successfully developed, and matched the main purposes of the prototyping. The required Q factors and accelerating gradients are achieved for QWR and HWR cavities.

ACKNOWLEDGEMENT

This work was supported by the Rare Isotope Science Project which is funded by the Ministry of Science, ICT and Future Planning (MSIP) and the National Research Foundation (NRF) of the Republic of Korea under Contract 2011-0032011.

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ISBN 978-3-95450-147-2