Superconducting RF Activities at Peking University

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1. Introduction

High brightness electron beams are required for a number of applications including short wavelength FELs. As superconducting photoemission source appears to be promising in producing high current, low energy spread, high brightness electron beams, it is suggested to develop a high brightness superconducting rf gun of photo cathode by joint efforts of related institutes in China. For this purpose the RF superconducting group at IHIP of Peking University decided to gear their activities in developing Nb cavities for high brightness electron sources. As a start a series of efforts have been made since fall 1988 to construct a class 100 laboratory suitable for processing and assembling of Nb cavities, as well as to develop equipments and techniques for designing, surface treatment and RF test of superconducting cavities. The fields of fundamental and high-order modes, as well as wake field potentials, were studied using the SUPERFISH, URMEL and TBCI codes during design.[1] Two high-purity L-band Nb cavities were kindly sent to us from DESY and Cornell to facilitate the development. In this paper the preparation of the Nb cavity made by Donier and the structure of the cryostat is described and preliminary results of Q versus temperature are presented and discussed. An accelerating field of 8.6 Mv/m was obtained with a Q_0 of 6.5×10^8 at 2.25k.

In addition, coaxial and pillbox cavities were designed and constructed for the test of RF properties of high Tc YBaCuO samples developed by superconductor groups in the Department of Chemistry, Peking University. Results of these tests are also presented.

2. Preparation of the Nb cavity

A 1.5-GHz single cell cavity, made of high-RRR (300) Nb, with a size and shape similar to that of Cornell resonators, was manufactured by Donier Co., and the final cleaning and chemical polishing work were implemented on the base of their preliminary treatment. However, for a high-RRR Nb cavity, it is necessary to consider the Q-degradation effect due to the thermal cycling to a temperature below 200K or to the slow cool-down processes observed in various labs.[2]

The postpurification of the Nb surface was done with the following procedure:

- First chemical polishing (CP) removes by 20 μm of inner surface in $HF/HNO_3/H_3PO_4$ solution, using the DESY method[3]
- Rinsing with demineralized water ($\rho \geq 10$ MΩ–cm)
- Drying by pumping
- Heat treatment with Titanium box at 850°C for 1.5 hours
- Second chemical polishing removes by 5–10 μm of inner surface
- Rinsing again with DI water first, then with ultrapure water ($\rho \geq 18$MΩ–cm)
- Move to a clean room of class 100
- Rinsing again with ultrapure water
- Assembling on a superclean bench
- Vacuum evacuation and baking at 150°C for 20 hours
- Mounting the cavity onto a vertical stand.

The above method is our first test, we will improve our procedure according to the results of our test and the method of other labs.

3. The Cryostat

The cryostat for the L-band Nb cavity was manufactured by the Department of Physics, Peking University. The length is about 175 cm and the diameter 65 cm. The Nb cavity is mounted vertically in the cryostat (Fig. 1) and evacuated separately by TMP and ion pump. Liquid He is fed from a big Dewar by a transmission line. No HOM coupler and frequency tuner are provided at the moment. Outer magnetic shield is wrapped by a high μ material foil. To reach a temperature as low as 2K, a depressure system is used.

4. Experiment and Results

The vertical test of 1.5 GHz Nb cavity has been carried out since the end of last year. A high stability RF signal is provided by an HP 8663A signal generator, while sampling and control are completed by HP 54503A digital oscilloscope and HP PC-312 controller, respectively. Reliable RF cable and connectors are used for low temperature area inside the cryostat, and every element was checked and calibrated before the test. A phase locked loop has been used under the superconducting condition. The pulse method was adopted for Eacc and Q_0 measurements. The decay time of the pickup signal from the SC cavity and coupling coefficient (β) of the main coupler are measured with pulsed RF power at various field levels. From those data, Q_0 and Eacc are calculated. The unloaded Q value (Q_0) of the cavity is calculated from Q_1 and β with the equation $Q_0 = Q_1\,(1+\beta)$.

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The acceleration field Eacc on the beam axis is calculated from Q_0 and β, using the following equation:

$$E_{acc}=\frac{1}{0.1}\sqrt{102\cdot Q_0\cdot\frac{4\beta}{(1+\beta)^2}\cdot P_t}$$

Here, factor ($102\cdot Q_0$) is the cavity's shunt impedance. Pt is the input RF power.

Fig. 2 is the curve of Rs vs. Tc/T. In the figure, the dots represent the measured data, the line is a theoretical curve given by BCS theory. The dots fall well on the line till Tc/T greater than 4.0. Then they deviate from the theoretical value considerably, which in turn show the existence and value of Rres.

Fig. 3 gives two curves of Eacc vs. Q_0. One is the data measured at 4.2K, while the other is at 2.2K. The Eacc max so far reached is 8.6Mv/m ($Q_0=6.5\times10^8$, f=1.46GHz) at 2.25K. The maximum value of Eacc in the test was actually limited by RF power available.

5. R&D of HTS

We are interested in RF superconductivity of high Tc material and its applications in accelerating cavity. For this purpose, an coaxial resonator and a pillbox cavity have been used for RF properties tests of YBaCuO film sample. Large-area high-Tc film with good quality is made by an electrophoresis deposition,[4] provided by the Department of Chemistry, Peking University. The RF properties were tested in our lab. Working frequency is around 0.5–1.2 GHz for the coaxial resonator and about 9–10 GHz for the pillbox cavity. The results of preliminary experiments show considerable RF superconductivity. At 77K, Rs=(220±30)mΩ (pillbox cavity, f=9.8 GHz, TE011), and for the coaxial resonator Rs=(0.8±0.1)mΩ with f=1.0 GHz.

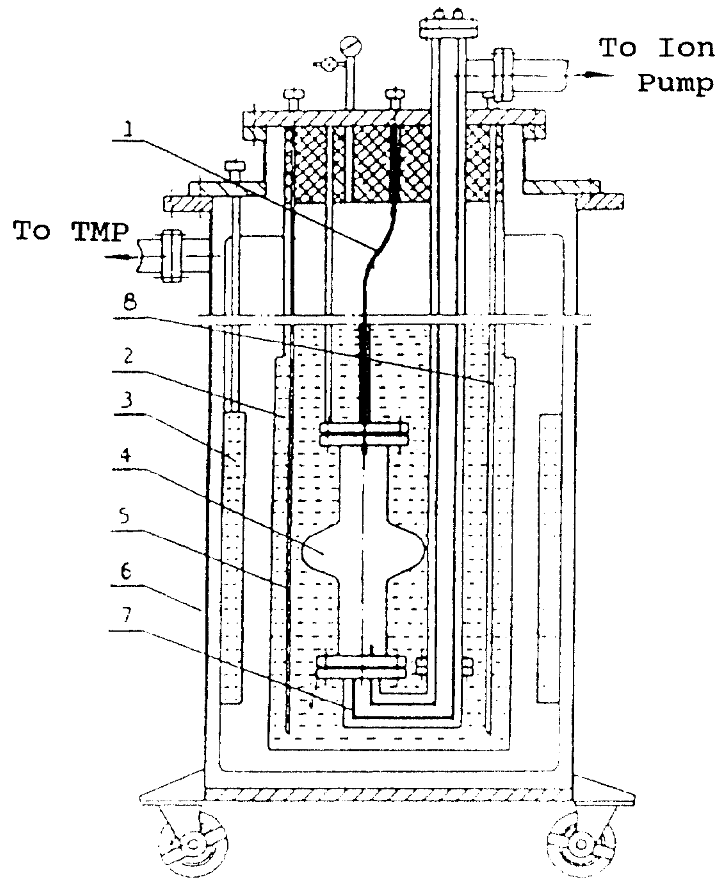

Fig.1. Sketch of Cryostat

1. Coupler
2. LHe-Vessel
3. LN-Shield
4. Nb-Cavity
5. LHe Level Meas.
6. Tank
7. Pick-up Probe
8. LHe Transmission Line

6. Acknowledgement

We would like to express our thanks to Dr. D. Proch for his continuous support and help. We are also pleased to acknowledge Dr. H. Padamsee (Cornell University), and Dr. T. Weiland for their kind encouragement and help.

References

[1] C. Chia-erh, Z. Kui, Z. Baocheng, W. Lifang, S. Jinhu, Proceeding of the 4th Workshop on RF Superconductivity, 859, (1990).

[2] R.W. Roth et al., EPAC 90, Nice, June, 1990. R. Byrns et al., EPAC 90, Nice, June, 1990.

[3] D. Proch et al., DESY M-84-10, July (1984).

[4] G. Mueller, Proceeding of the 4th Workshop on RF Superconductivity, 267 (1990).

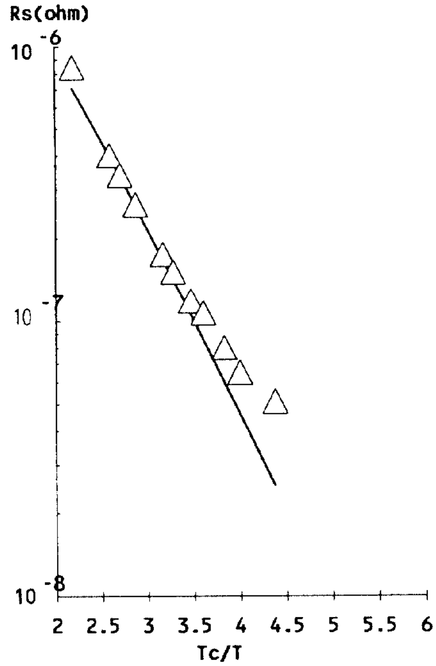

Fig.2. Rs vs. Tc/T

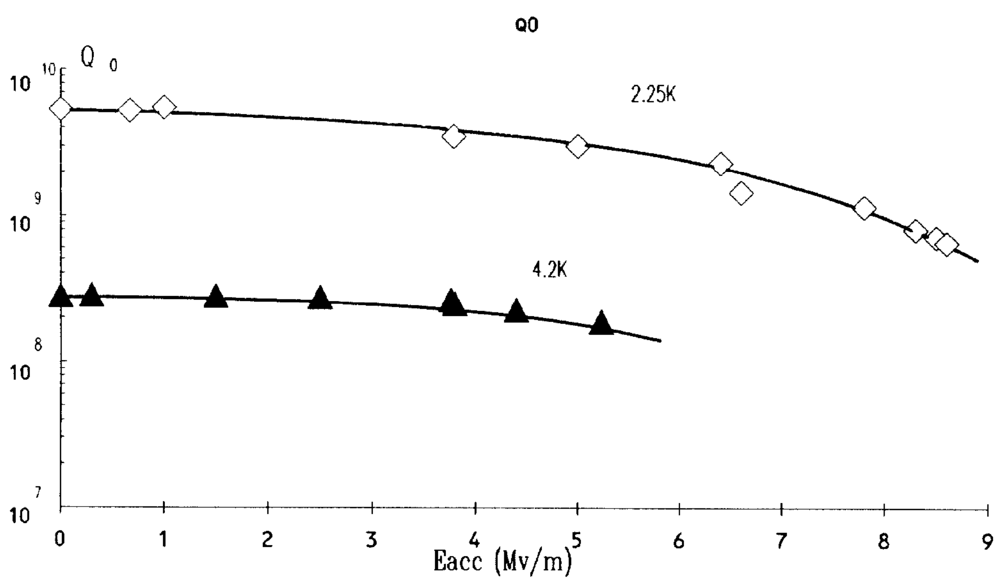

Fig.3.
Quality factor vs. accelerating field for single cell 1.5GHz cavity