TEST RESULTS OF SUPERCONDUCTING CAVITIES PRODUCED AND PREPARED COMPLETELY IN INDUSTRY

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Abstract

Superconducting cavities generally have been prepared for operation by the laboratory using the cavities for own purpose. For a number of recent projects ACCEL is producing and preparing the cavities including the rf testing of cavities or accelerating modules ready for operation. We report on test results of those cavities. The preparation of the cavities includes chemical treatment (BCP), rinsing with high pressure water and assembly in a clean room. The following cavity types were or will be treated: 400 MHz single cell cavities for LHC, 500 MHz single cell cavities of the Cornell CESR design for our superconducting accelerating modules, 1300 MHz TESLA type cavities, 176 MHz and 160 MHz half-wave resonators and a 352 MHz CH-mode cavity for ion acceleration.

INFRASTRUCTURE AT ACCEL

The infrastructure for surface preparation of cavities at ACCEL contains mainly the chemical plant for surface treatment with BCP 1:1:2 and the high pressure rinsing system.

Chemical Plant

The chemical plant is designed for treatment of cavities with a maximum height of 2 m and a maximum diameter of 1 m.

The chemical plant is located in a dedicated building used only for BCP treatment. The acid mixture used for the surface treatment is standard BCP 1:1:2. The acid is flowing in a closed loop and is cooled to temperatures below 15 °C to avoid hydrogen diffusion into the niobium during the chemical etching and thus avoiding Q disease. No Q disease has been observed on any of the treated cavities.

After chemical treatment, the cavity is immediately rinsed with deionised water until the resistivity of the water is better than 0.01 MΩ/cm. At that time the flanges and seals used for chemical treatment are exchanged and the rinsing is continued until a resistivity of 17 MΩ/cm is reached.

High Pressure Rinsing Facility

There are two high pressure rinsing systems installed. Both are located in a nominal class 100 clean room.

One rinsing system is dedicated to cavities with larger volumes like the 500 MHz single cell cavities of the Cornell type, the others for smaller volume cavities like TESLA type cavities. Both installations are using the same pump. The pressure of the water is 100 bar and the resisitivity of the water is 17 MΩ/cm. We are using a stainless steel wand with sapphire nozzles at the head of the wand. Typically there are 9 nozzles in one head. The wand is moved up and down during the rinsing and is rotating alternately 180° clockwise and counter clockwise. By this no rotating feedthrough is required between the hose and the rinsing wand. Depending on the size of the cavity the rinsing time is between two and four hours.

PREPARATION PROCEDURE

All bulk niobium cavities are prepared in a similar way as follows:

- Ultrasonic degreasing
- BCP 1:1:2, removal of at least 20 microns
- Rinsing with deionised water until a resistivity of 17 MΩ/cm is reached.
- High pressure rinsing with 100 bar deionised water
- Drying by pumping
- Venting with filtered ultra-clean dry nitrogen
- Assembly of test equipment (antennas and pick-ups, all metal valve, etc.)
- Pump-down and leak-check

For pump-down and leak-check pumps dedicated only for cavities are used. Pump-down and venting is always done in the laminar flow regime (20 mbar/min). After connection of the pumping line, the line is pumped and purged three times before the valve to the cavity is opened.

Figure 1: Single cell 400 MHz LHC cavity before sputtering with niobium.

SINGLE CELL 400 MHZ CAVITIES (LHC)

The preparation of the Nb/Cu sputtered cavities is similar, but additionally requires introduction of the Nb liner(the cathode), baking of the cavities and SUBU chemistry of the copper cavities instead of BCP chemistry. The final rinsing and assembly of the niobium coated cavity is done using only 5 bar water pressure.

The preparation of the Nb/Cu cavities produced and prepared for vertical test in the years 1997-1999 are reported in detail already in [1]. The main results are shown here again in Figure 2 and 3 in order to demonstrate the high performance of these cavities with almost 1 square meter of rf surface.

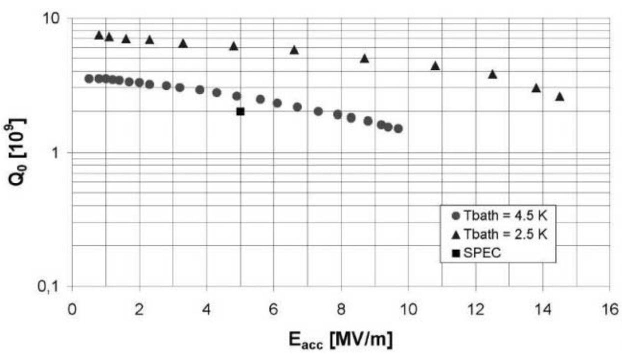

Figure 2: Typical result of a 400 MHz Nb/Cu plated cavity for LHC produced and prepared at ACCEL. The RF test was performed at CERN.

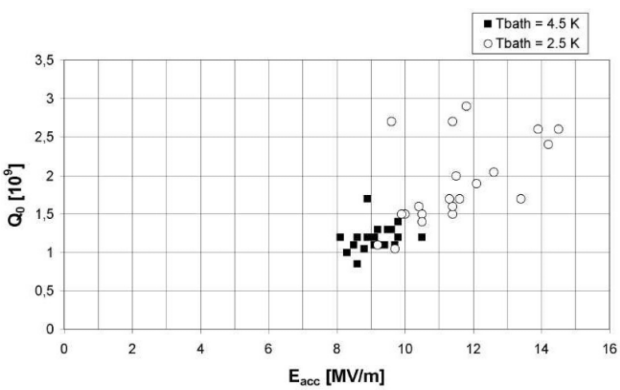

Figure 3: Highest gradients E_{acc} and quality factors Q_0 at the highest gradients achieved at bath temperatures of 4.5 K and 2.5 K in the 21 LHC 400 MHz single cell cavities. The tests were carried out at CERN.

SINGLE CELL 500 MHZ CAVITIES (CORNELL CESR DESIGN)

Up to now we have produced ten 500 MHz single cell cavities of the Cornell CESR design and prepared 6 of those cavities for vertical test. The vertical test is done at Cornell using their RF and cryogenic infrastructure. The cavity is shipped after preparation in a special transport box on shock absorbing bumpers.

The preparation of those cavities is challenging, as the cavity has to be sealed by three large indium seals on both beam-pipe sides and at the waveguide in the cleanroom without contaminating the cavity again (see Figure 4).

Figure 4: Three 500 MHz cavities of the Cornell design after production and prior preparation.

Figure 5 summarizes the RF test results. All cavities show similar behaviour. The maximum gradient of about 12 MV/m is limited by available RF power during the vertical test. A gradient of 12 MV/m is equivalent to a voltage of 3.6 MV in the single cell. No performance degradation of cavity behaviour was observed after assembly of the cavity into the accelerator modules.

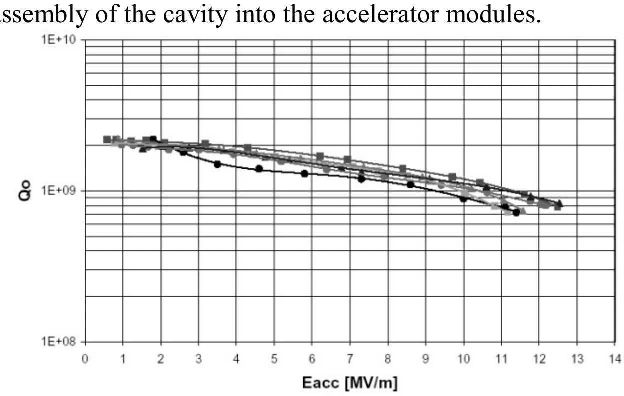

Figure 5: Summary of test results on 500 MHz single cell cavities of the Cornell design. All cavities show similar behaviour during RF test showing the reliable preparation procedure.

NINE CELL 1300 MHZ CAVITIES (TESLA)

Two 1.3 GHz TESLA cavities have been prepared at ACCEL for vertical test so far. The preparation including tuning to field flatness was done this spring. Figure 6 shows one of the cavities during the high pressure rinsing procedure.

Figure 7 and 8 shows the results of cavities BE1 and BE2. The RF test was performed at DESY. The two cavities were produced for BESSY for FEL studies. During preparation of the first cavity (BE2) a leak occurred and the cavity needed to be vented and sealed again. In addition, this cavity was shipped under N2 atmosphere whereas the second cavity (BE1) was shipped under vacuum. Shipping under vacuum has the advantage that one only needs to open the all metal valve located at the cavity after pumpout of the insert pump line. Thus there is no risk of contaminating the cavity by dust accumulated in the pumping line.

Figure 6: High pressure rinsing of a nine cell 1300 MHz TESLA cavity at ACCEL.

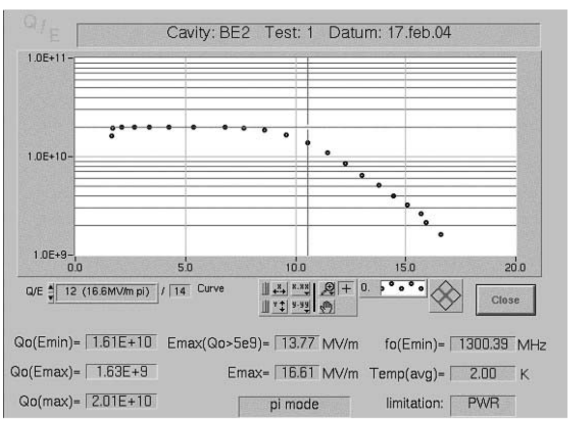

Figure 7: Test result of first prepared TESLA cavity BE1. Field emission was observed above 10 MV/m.

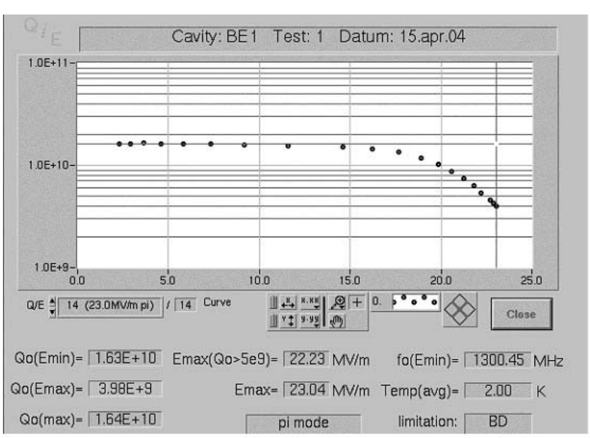

Figure 8: Test result of second prepared TESLA cavity BE2. No field emission was observed. The Q drop at highest fields is without indication of x-rays. The cavity was limited at 23 MV/m by a quench.

Cavity BE1 is now at ACCEL for the helium vessel welding. After that they will be prepared at ACCEL for horizontal test. The needed input power couplers of the TTF III style were produced also at ACCEL and have been conditioned on a test stand at DESY already. The horizontal test of the cavities will be done at BESSY.

HWR 176 MHZ AND 160 MHZ CAVITIES

This summer two HWR cavities have been treated in our facilities. The 160 MHz cavity for Forschungszentrum Jülich is currently under test at Jülich and the 176 MHz cavity for the SARAF Linac is currently tested at Frankfurt University. Figure 9 shows the chemical treatment of this cavity at our place

Figure 9: First HWR 176 MHz cavity during chemical treatment at ACCEL.

CH-MODE 352 MHZ CAVITY

A 352 MHz CH-mode cavity is under production at ACCEL. Figure 10 shows a CAD model of this CH-Mode Cavity. We plan to have the niobium cavity finished within one ore two months. The chemical preparation and high pressure rinsing of this cavity will follow then immediately and the RF test will be performed at University Frankfurt.

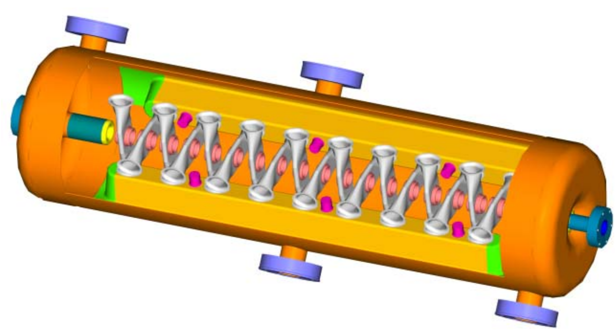

Figure 10: Cut view of the 352 MHz superconducting CH mode cavity.

REFERENCES

[1] S. Bauer et al., Production of Nb/Cu Sputtered Superconducting Cavities for the LHC, 9th workshop on RF superconductivity, Santa Fe, New Mexico, 1999.