SUPERCONDUCTING MATERIALS TESTING WITH A HIGH-Q COPPER RF CAVITY*

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Abstract

Superconducting RF is of increasing importance in particle accelerators. We have developed a resonant cavity with high quality factor and an interchangeable wall for testing of superconducting materials. A compact TE01 mode launcher attached to the coupling iris selectively excites the azimuthally symmetric cavity mode, which allows a gap at the detachable wall and is free of surface electric fields that could cause field emission, multipactor, and rf breakdown. The shape of the cavity is tailored to focus magnetic field on the test sample. We describe cryogenic experiments conducted with this cavity. An initial experiment with copper benchmarked our apparatus. This was followed by tests with Nb and MgB_2. In addition to characterizing the onset of superconductivity with temperature, our cavity can be resonated with a high power klystron to determine the surface magnetic field level sustainable by the material in the superconducting state. A feedback code is used to make the low level RF drive track the resonant frequency.

DESCRIPTION OF APPARATUS

The system [1], which resonates at ~11.424GHz, consists initially on a TE_{10} height taper, a planar TE_{10} to TE_{20} mode converter and a rectangular TE_{20} to cylindrical TE_{01} mode converter as shown in Figure 1.

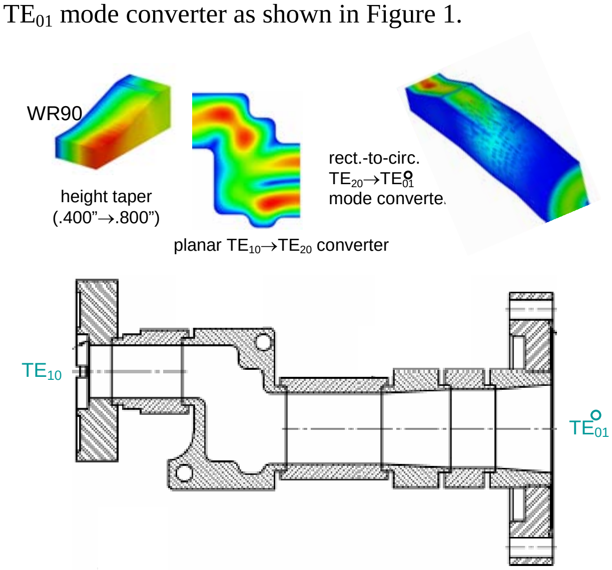

Figure 1: WR90-WC150 compact high-purity TE01 mode launcher.

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Finally, a mushroom-type cavity is attached to the mode launcher, where material samples are placed at the bottom flange. Figure 2 shows this cavity.

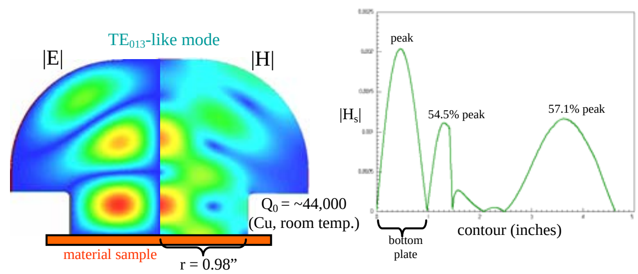

Figure 2: Electric and magnetic fields in the “mushroom” cavity (left) and magnetic field profile along the surface of the cavity (right).

Main Features

- X-band frequency allows for already available high power and RF components.
- Fits in cryogenic Dewar.
- Requires small samples (3”).
- Mushroom-type cavity guarantees no surface electric fields, i.e. no multipactor.
- Magnetic field concentrated on bottom (sample) face, where it is 75% higher than anywhere else.
- Purely azimuthal currents allow demountable bottom face (gap).

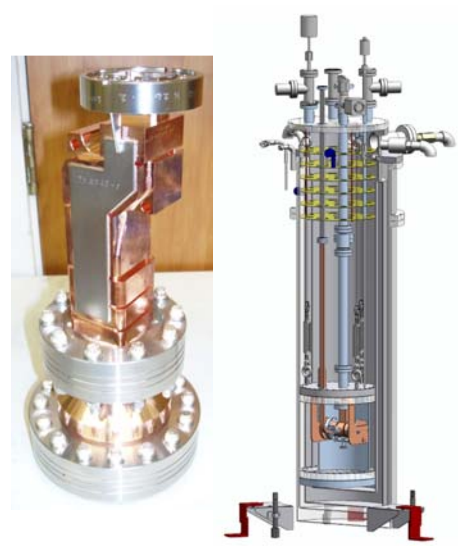

Figure 3: Picture of mushroom cavity attached to the mode launcher (left), and cryogenic Dewar drawing (right).

In Figure 3 it is shown a picture of the cavity and mode launcher and the Dewar assembly drawing.

COPPER AND NIOBIOUM TESTS

Tests with copper and niobium samples have been performed successfully, and the quality factors are shown in Figures 4, 5, 6 and 7.

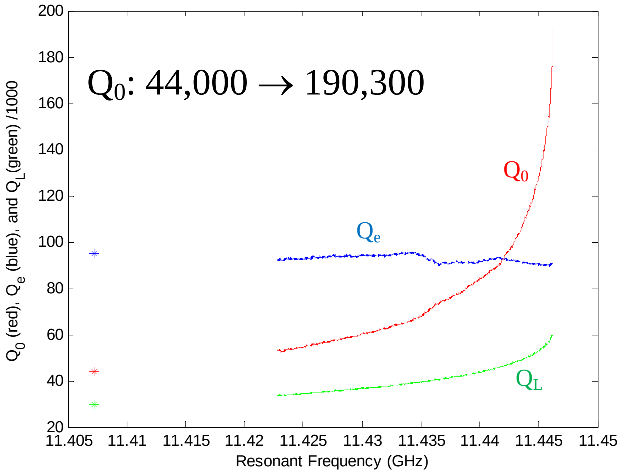

Figure 4: Quality factors with copper sample in bottom flange as a function of frequency.

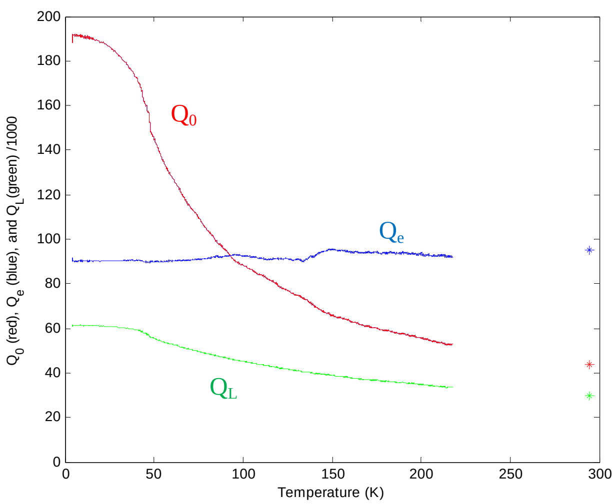

Figure 5: Quality factors with copper sample in bottom flange as a function of temperature.

Figure 8 shows the transition of cavity Q_0 during warm-up from liquid helium temperature for reactor grade niobium. The graph shows a very sharp and clean change as the niobium sample undergoes the phase transition around 9.3 K.

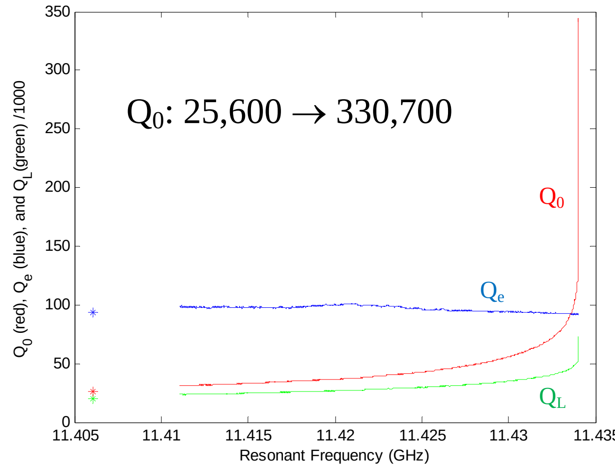

Figure 6: Quality factors with niobium sample in bottom flange as a function of frequency.

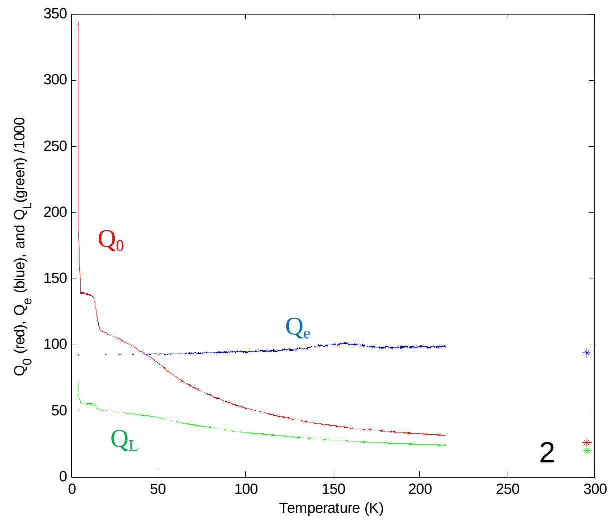

Figure 7: Quality factors with niobium sample in bottom flange as a function of temperature.

MgB_2 TEST

A sample prepared by Superconductor Technologies Incorporated (STI), where MgB_2 was coated on top of sapphire, has been tested. The thickness of the MgB_2 layer is ~500nm and the method of coating is reactive evaporation (RE) [2]. A first low power test of the film is shown in Figure 9, where a clean Q drop is observed at the transition temperature.

The presented system also allows for the determination of the surface resistance by considering the difference between the copper sample results and the other material samples. A preliminary estimation of the surface resistance for the MgB_2 sample is shown in Figure 10.

form the cavity reflection. A silicon diode and a Cernox temperature will be also added.

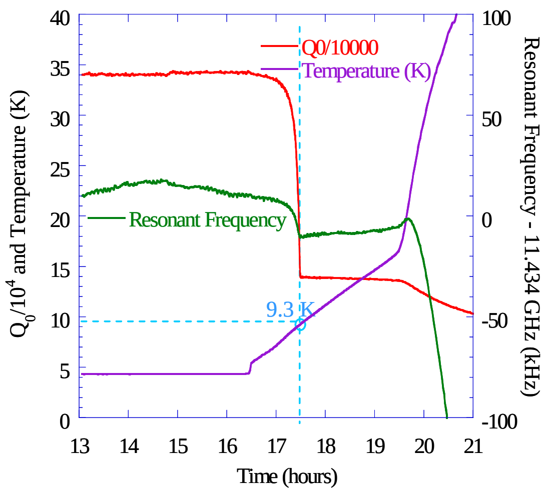

Figure 8: Transition of Cavity Q_0 during warm-up from liquid helium temperature for reactor grade niobium.

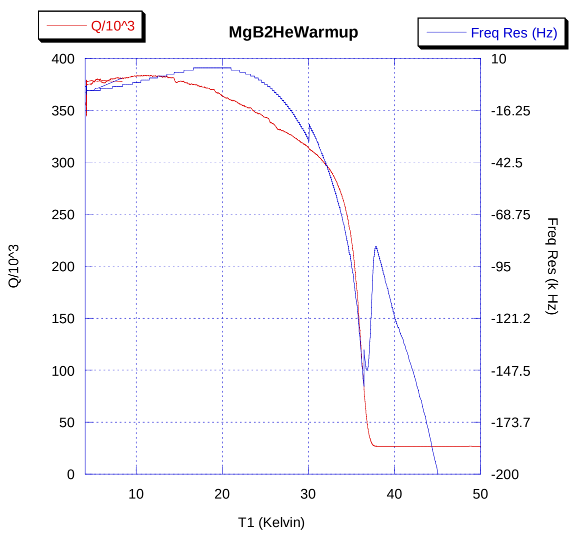

Figure 9: Qualify factor temperature dependence of STI MgB2 sample during warm-up.

HIGH POWER TEST

A high power test has been performed on niobium for the calculation of the RF critical magnetic field. Given the geometry of the cavity and the expected critical field for niobium, it can be shown that the required power to achieve a magnetic quench with a 1.5μs flat input pulse is P_c = 498kW.

Figure 11 shows preliminary data of the high power test for reactor grade niobium at 4.2 K.

The experimental setup is still maturing. A high-power circulator will be added in order to isolate the klystron

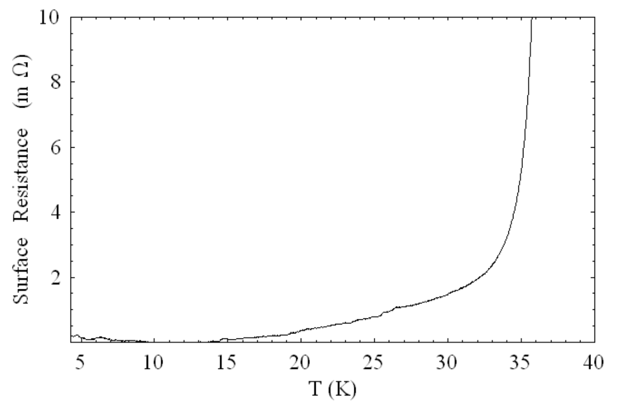

Figure 10: preliminary calculation of the surface resistance for the MgB_2 sample.

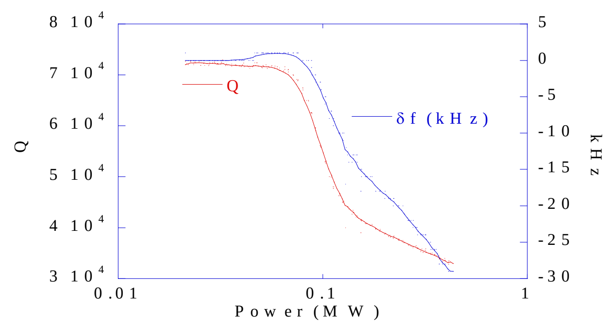

Figure 11: High power test of niobium at 4.2K .

CONCLUSIONS

A compact, high-Q RF cavity optimized for economically testing the RF properties of material samples and their dependence on temperature and fields by means of frequency and Q monitoring has been designed and fabricated at SLAC.

Tests on copper, niobium and MgB_2 samples have been performed.

High power tests are underway and a similar cavity will be used for pulsed heating material testing.

REFERENCES

[1] C. Nantista et al., "Test Bed for Superconducting Materials", *Proceedings of the 21st Particle Accelerator Conference (PAC05)*, Knoxville, TN, May 16-20, 2005, p. 4227.

[3] T. Tajima et al., "Tests on MgB2 for Application to SRF Cavities", *Proceedings of the European Particle Accelerator Conference (EPAC06)*, Edinburgh, United Kingdom, June 26-30, 2006.