RADIO FREQUENCY SUPERCONDUCTING STRUCTURES DEVELOPMENT LABORATORY CAPABILITY AT LOS ALAMOS NATIONAL LABORATORY*

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Abstract

Los Alamos National Laboratory has established an in-house capability to pursue development of superconducting rf structures. Facilities including test pits, shielded cryostats, an ultrapure 500-gal. water system, a 600-ft^2 clean assembly area, and a helium pumping system have been installed and are now operational. High-field testing on cavities at 810 and 3000 MHz is progressing. This paper presents a facility description and recent cavity measurement results.

Introduction

Over the past three years, the Accelerator Technology Division of the Los Alamos National Laboratory has established a capability to work with superconducting accelerating structures. This capability includes designing, forming, and welding niobium cavities, chemically polishing and cleanly assembling the structures on cryogenic test fixtures, and testing the cavities at power with temperatures from 3.97 K to 1.7 K.

To date, we have designed and constructed cavities resonant at 810 MHz and 3000-MHz. The cavity type is the so-called elliptical cavity. We have fabricated 11 cavities at 3000 MHz. The tests conducted at this frequency use temperatures around 1.7 K, which are achieved by pumping on a bath of liquid helium. We have built two cavities at 810 MHz and have performed tests at this frequency at 3.97 K. All cavities are made of high RRR niobium (RRR > 250).

Measurements

Present testing at 3000 MHz is devoted to developing a distribution of field measurements to establish a base line of performance. To date, we have performed 7 high-field tests, of which 3 have had rf processing. A value representative of the highest levels achieved so far is 42 MV/m peak electric field at a $Q_0 = 1.6 \times 10^9$. Fig. 1 shows the behavior of the cavity Q_0 over the electric field range.

We have performed fewer tests at 810 MHz, because of the increased helium consumption and handling complexity. So far, 4 tests have yielded field levels as high as 25.4 MV/m peak electric field at a $Q_0 = 2.4 \times 10^9$. We have performed these tests at 3.97 K and have intentions to run them at around 2 K in the future. Fig. 2 shows a Q_0 versus peak electric field result for the 810-MHz cavity.

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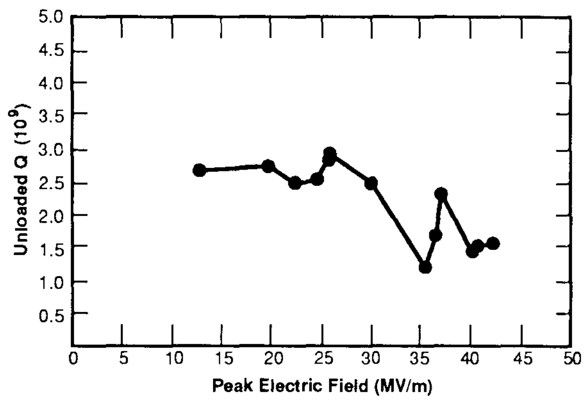

FIG. 1. Plot of Q_0 vs peak electric field, 3000 MHz single cell cavity.

For both cavity types, we have placed emphasis on refining the chemical polish, rinse, and clean assembling. With processing of this kind, that is no heat treatment, the values obtained thus far are commensurate with those achieved by the international superconducting cavity community using similar techniques[1,2].

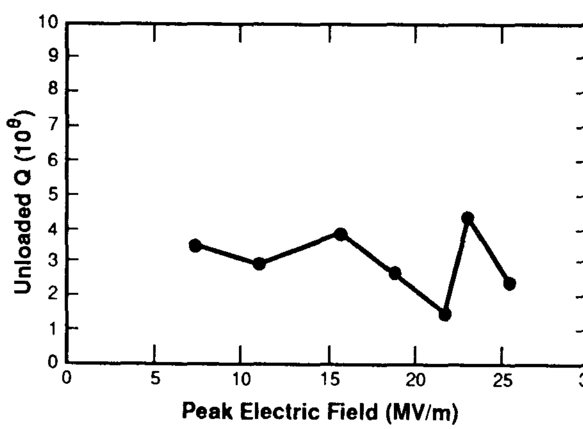

FIG. 2. Plot of Q_0 vs peak electric field, 810-MHz single cell cavity.

Facility

Facilities for cavity processing are in place that allow the cavities to be chemically polished, rinsed with ultrapure water, assembled in a clean room, and tested under high vacuum in shielded cryostats. The present setup can fully polish, assemble, and test up to a single-cell 810 MHz cavity; for a single-cell 400-MHz cavity, the setup provides clean assembly and testing.

Chemical polishing is done off site, using with a dip method that is applicable for up to single-cell 810-MHz cavities.. The polishing solution is an equal mixture of concentrated nitric, hydrofluoric, and phosphoric acids. After the cavities are polished, they undergo four immersion rinses in deionized water. The cavities are weighed between polishes to determine material removal.

In the interest of working with larger cavities. We have designed and specified a piped chemical polishing system such that it is ready to be released on bid. The system uses teflon lined steel pipes and tanks to insure purity and containment, as well as a full sensing and status capability for programmable process control. The system will be capable of handling 50 gallons of acid, 150 gallons of clean water, and 250 gallons of waste water.

After chemical polishing, the cavity is rinsed with ultrapure water inside the clean room. The water system has a 500-gallon capacity, with a 2200-gallon-per-day makeup ability. The water quality has been measured as better than ASTM Electronics Grade E-1, as shown in Table 1.

TABLE 1.
Specified and measured values for the ultrapure water system.

Water Quality:	Specifications	Measurements
Resistivity (MΩ-cm)	18	18.2
Silica (μ g/l)	5	2.0
Particulate (1μ m/ml)	2	0
Micro-organisms (per ml)	1	<1
TOC (μg/l)	50	6.9
Copper (μ g/l)	1	0.5
Chloride (μg/l)	2	0.8
Potassium (μg/l)	2	2.0
Sodium (μ g/l)	1	1.0
Residual solids (μg/l)	10	<5
Zinc (μg/l)	5	2.0
Additional Requirements:		
Resistivity	>18 MΩ-cm	18.2
Total Organic Carbon	<50 ppb	6.9
Particulate	<25 Particles >0.1μ m per liter	0 >.5μm / 100 ml
Bacteria	<1 CFU/100 ml	<1
Total Residue	<0.1 ppm	<.005
Dissolved SiO_2	<5 ppb	2.0
Iron	<2 ppb	1.0

The clean assembly facility covers approximately 600 square feet, which includes the clean room laminar downflow unit, the anteroom, and the gowning area with its own downflow unit. Measurements on the different areas of the clean room were carried out with a laser particle counter in accordance with Federal Standard 209D. The bona fide clean room covers 100 square feet and was measured to meet the acceptance criteria for class 10 at rest. Additionally, the anteroom and the gowning area also met the acceptance criteria for class 10 at rest.

The operational value for the clean area (with personnel present) is more a matter of interpretation. Particulates off the gowns can push measured values for the lower part of the room, below the gown, to values meeting the criteria for class 100. But, above the gown, values are still consistent with class 10. These values indicate that good technique and care can go far in giving better results. We take advantage of the situation by working on the cavity from below and not entering the entrance plane above the cavity without rinsing the cavity afterwards. Future upgrades will include a gown more consistent with class 10 operation.

Additional facilities include 4 vertical test cryostats, which range in liquid helium capacity from 75 liters to 1700 liters. These cryostats are serviced by a 100-cfm roots blower package, which pumps on the liquid helium bath and reduces the operating temperature of the cavities.

Conclusion and Discussion

The Accelerator Technology Division at Los Alamos National Laboratory is developing a capability to build superconducting accelerating structures. To date, niobium cavities have been fabricated and run to levels comparable to values achieved at other established superconducting labs using similar processing steps.

Present efforts are focused on performing a sufficient number of tests to establish a statistically valid distribution of the field levels achieved. In addition, development is continuing on a high-pressure rinse system and a high-temperature vacuum oven to extend the possible combinations for cavity processing.

Acknowledgments

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References

1. H. Padamsee, et. al., Proceedings of the 4th Workshop on Rf Superconductivity, Tsukuba, KEK Report 89-21 (National Laboratory for High Energy Physics, KEK, Tsukuba, Japan, 1989, Y. Kojima, Ed.).

2. H. Piel, private communication