STATUS OF NIOWAVE/ROARK ILC VENDOR QUALIFICATION TESTS AT CORNELL*

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Abstract

To build the ~14,000 cavities required for the ILC each of the three world regions must have a sizable industrial base of qualified companies to draw cavities from. Two of these companies, Niowave Inc. and C.F. Roark Welding & Engineering Co., Inc, recently manufactured six 1.3 GHz single-cell cavities for qualification purposes. All six cavities achieved gradients above 25 MV/m before they were limited by the available RF power (Q-slope) or quenched. This paper will report the results of cold tests for all six cavities and on the causes of quench determined by 2nd sound detection and optical inspection.

INTRODUCTION

The work presented here reports on cavity colds tests performed to pre-qualify a new vendor's fabrication procedures as quickly as possible, for the production of TESLA-style ILC cavities. The new vendor is the American cavity manufacturing collaboration between Niowave, Inc., and C.F. Roark Welding & Engineering Co., Inc. In support of the pre-qualification Niowave/Roark manufactured six single-cell TESLA-style cavities. We discuss in the following two sections:

1) The cavity preparation and the results from the 2.0 K cavity tests.
2) The optical inspection of areas which were determined to be the source of quench during the cold tests.

CAVITY PREPARATION AND TESTING

Buffered Chemical Polishing and Processing

The pre-qualification goal of the cold tests performed here was to determine if the cavities were limited by defects to low-accelerating gradients, not to initially push the cavities to the highest possible quality factors and accelerating gradients. In support of this, the cavities were chemically polished with a 1:1:2 buffered chemical polish (BCP) at $T<17^0$C with the following procedure:

1) Cavity is packed in ice, figure 1.
2) Chilled (8^0C) 1:1:2 BCP is transferred to the cavity.
3) The BCP solution etches the cavity until the temperature rises to 15-16^0C.
4) The cavity is drained, rinsed with DI H_2O, and rotated 180^0
5) Steps 1-4 are repeated until the desired amount of material is removed.

After chemical polishing the cavities were prepared by:

1) Ultrasonically degreased in a 1% Alconox and 99% DI H_2O solution for 30 minutes.
2) Rinsed with DI H_2O
3) Ultrasonically cleaned in a DI H_2O bath for 30 minutes.
4) 2 hour high-pressure rinse in a class 10 cleanroom.
5) After drying for 24 hours the fundamental power coupler and the transmitted power coupler were installed in the same class 10 cleanroom.

Figure 1: BCP of a single-cell Niowave cavity packed in ice. The white Teflon rope supports a Niobium sample inside the cavity for material removal measurements.

Cavity Testing and Results

After the processing steps described above, the cavities were tested at 2.0 K in a vertical dewar. Each vertical test was equipped with two calibrated ruthenium oxide resistors for bath temperature monitoring and an array of 8 oscillating superleak transducers for quench-spot location, if necessary.

The RF performance for the BCP treated Niowave/Roark cavities is shown in figure 2. All of the cavities exhibited high-field Q-slope due to the heavy BCP treatments they received. Five of the cavities achieved continuous wave accelerating gradients greater than 25 MV/m. Of these five cavities only two were limited by defects, these defects will be discussed in the following section. The sixth cavity's (NR1-3, figure 2)

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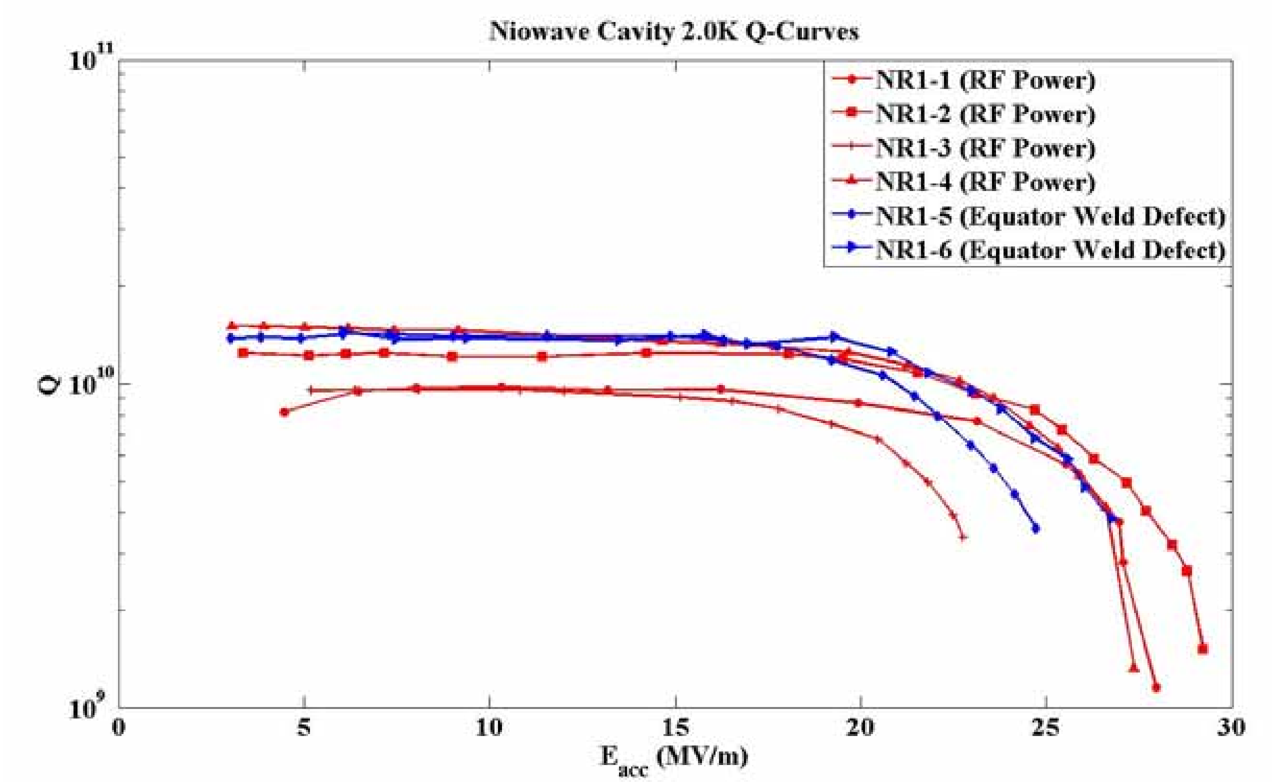

Figure 2: Q-curves for the six Niowave Inc. single-cell cavities tested at Cornell. All cavities exhibited the high-field Q-slope common to BCP cavities and two cavities quenched at equator weld defects.

maximum achievable continuous wave accelerating gradient was limited to 23 MV/m by Q-slope, but it did not quench. During pulsed operation this cavity attained accelerating gradients of 25 MV/m without quench.

DEFECT LOCATION AND OPTICAL INSPECTION RESULTS

2nd Sound Quench Location

All cavities tested were equipped with an array of eight oscillating superleak transducers (OST) to locate possible quench-spots during cold tests [2]. The eight OST were subdivided into two geometrically similar square arrays with one OST at each corner of the square and 12 cm from the cavity beam axis. One square array was located 10 cm above the equator weld and the second square array was located 10 cm below the equator weld. Refer to figure 3 for a photograph of a cavity ready for cold test.

Quench-spots were located by using at least three transducers to measure the time-of-arrival of the second sound wave generated by quench; additional transducers, when available, were used for consistency checks. The time interval between the cavity quench and the time-of-arrival of the second sound wave at each individual transducer is proportional to the distance. Using the experimentally inferred distance between the quench-spot and each transducer we are able to determine the quench location to a circular area of a few square centimeters, where we assume the defect is located at the origin.

Figure 3: A single-cell cavity ready for testing. Six of the eight oscillating superleak transducers are visible.

Optical Inspection

Two of the six Niowave/Roark cavities quenched and, in each case, the quench-spot was found to be near the equator weld. Following cold tests, which located the quench-spots, the interior cavity surfaces were inspected with a Questar long-distance microscope and a combined mirror/ light source.

In both cavities, optical inspection of the cavity RF surface found small pit-like defects on the equator weld where the second sound measurements located the quench-spots, figure 4 and figure 5. The defects are circular in shape and both have a radius of a few hundred micrometers. Both defects were optically located to be less than 1 cm away from the center of the circular area second sound measurements located as the quench-spot.

During the optical inspection of cavity NR1-6 we noticed two additional features on the equator weld with similar topologies to the defect shown in figure 5. The additional defects were farther away from the second sound located quench-spot and were discounted as the cause of quench. It is possible that they would initiate quench at higher field levels.

CONCLUSIONS

We presented the cold test results of six Niowave/Roark prototype single-cell 1.3 GHz TESLA-style cavities This work was performed to pre-qualify the Niowave/Roark partnership for the manufacturing of ILC cavities. The tests results show that they reliably produce cavities with accelerating gradients which exceed 25 MV/m. This constitutes a successful test of all of the manufacturing techniques needed to produce high performance superconducting cavities for the ILC.

At accelerating gradients exceeding 25 MV/m two of the six cavities were found to quench at weld defects. We are experimenting with repair techniques to further improve the gradients of these cavities and will report on the results of this work in the future.

REFERENCES

[1] Available at www.linearcollider.org

[2] Z.A. Conway, D.L. Hartill, H.S. Padamsee, and E.N. Smith, “Oscillating Superleak Transducers for Quench Detection in Superconducting ILC Cavities Cooled with He-II,” LINAC 08, Victoria, British Columbia, Canada, September 2008, pg. 850 (2008).

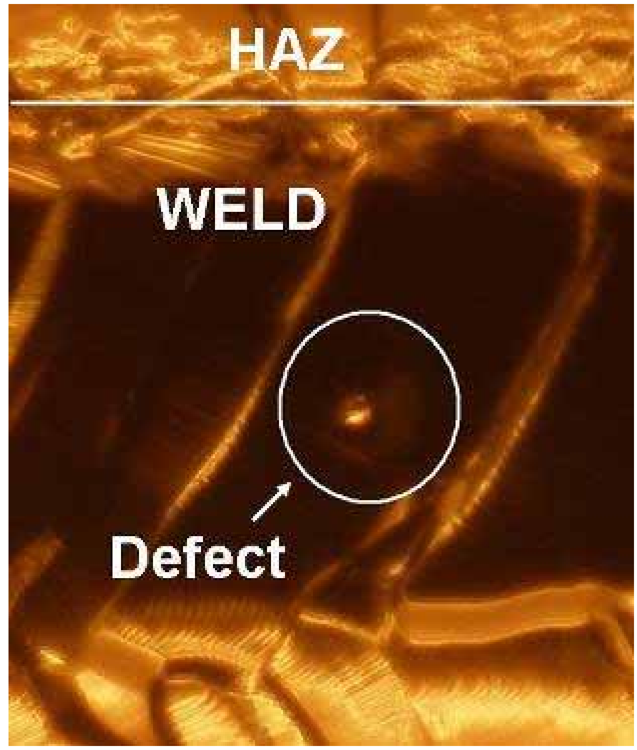

Figure 4: Defect in cavity NR1-5 located with second sound and optical inspection. The defect is inside the white circle. The border between the weld and the heat affected zone (HAZ) is delineated with a white line above the defect.

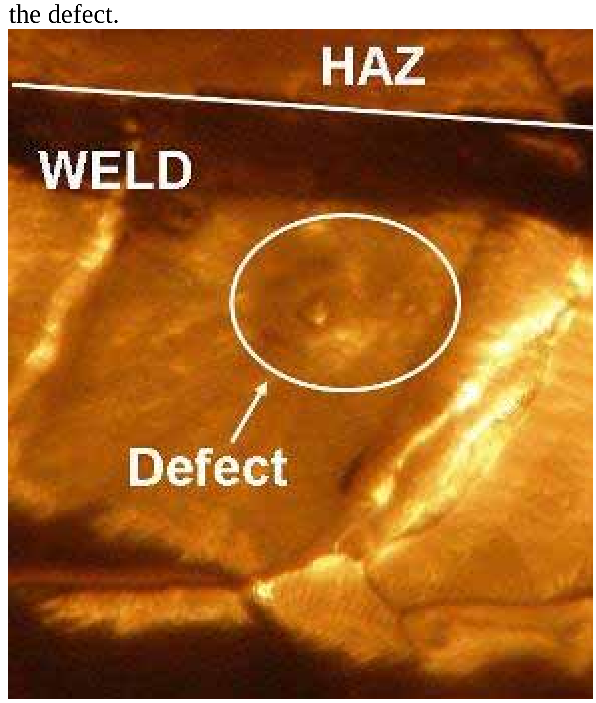

Figure 5: Defect in cavity NR1-6 located with second sound and optical inspection. Here the defect shape structure is more apparent than in figure 4. The defect is a heterogeneous protrusion, a mound with a shiny center, circled in white. The boarder between the weld and the heat affected zone (HAZ) is delineated with a white line.