FIRST HIGH-GRADIENT TESTS OF THE SINGLE-CELL SC CAVITY WITH THE FEEDBACK WAVEGUIDE

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Abstract

Use of a superconducting travelling wave accelerating (STWA) structure with a small phase advance per cell rather than a standing wave structure may provide a significant increase in the accelerating gradient in the ILC linac [1]. For the same surface electric and magnetic fields the STWA achieves an accelerating gradient 1.2 larger than TESLA-like standing wave cavities. In addition, the STWA allows longer acceleration cavities, reducing the number of gaps between them. However, the STWA structure requires a SC feedback waveguide to return the few hundreds of MW of circulating RF power from the structure output to the structure input. A test single-cell cavity with feedback was designed and manufactured to demonstrate the possibility of a proper processing to achieve a high accelerating gradient. The first results of high-gradient tests of a prototype 1.3 GHz single-cell cavity with feedback waveguide will be presented.

SINGLE CELL CAVITY PERFORMANCE

Two test single cell cavities were manufactured at Advanced Energy System, Inc. (AES), as shown in Figure 1. Table 1 lists the main RF parameters for 1-cell model of travelling wave cavities. Both cavities were optically inspected upon receiving. Several round features were present inside the cell equator weld both before and after chemical etching as shown in Figure 2 and Figure 3, which do not limit the cavity performance as indicated later.

Table 1: RF parameters for accelerating mode

Parameters	Accelerating mode	Waveguide mode
Epk/Eacc	2.205	14.876
Bpk/Eacc [mT/(MV/m)]	3.625	28.25
Cavity length [m]	0.06736	0.06736
Kappa[sqrt(R/Q)/L]	133.61	30.388
Frequency [MHz]	1,265.725,950	1,288.361,400

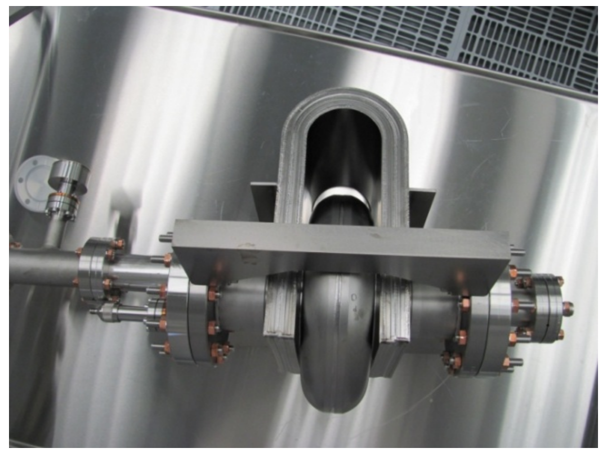

Figure 1: 1-cell model of a travelling wave cavity assembled for evacuation.

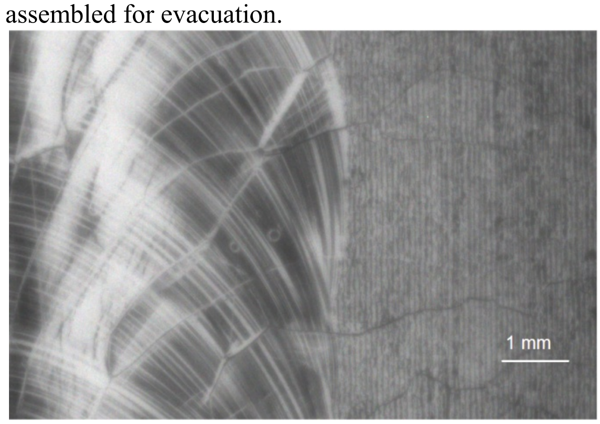

Figure 2: Round features inside equator weld identified by optical inspection before chemical etching.

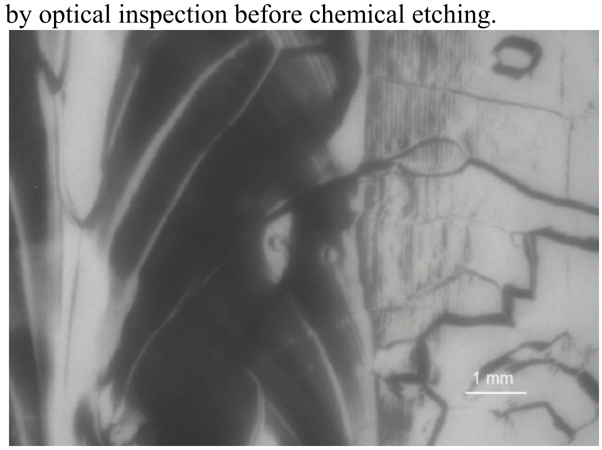

Figure 3: Round features inside equator weld identified by optical inspection after chemical etching.

Chemical etching

Buffer Chemical Polishing (BCP) using 2:1:1 solution (85% H_3PO_4, 49% HF and 70% HNO_3) removed total about 120 µm surface material. Chemical etching was accomplished through multiple fill and drain while cavities were in vertical position. Cavities were flipped upside down after first 60 µm surface material was removed. The maximum acid temperature was 17.6 °C for both 1-cell cavities. Cavity material removal was measured through total cavity weight reduction.

Cavity preparation

Both 1-cell cavities were ultrasonically rinsed in warm soapy water before rinsed by high pressure DI water. Water residual inside cavity was evident after 18 hour clean room drying. Slow evacuation was at extended 8-hour compared to usual 3 hour for TESLA shape 1-cell cavities.

RF performances

Multipacting was observed in accelerating mode for both cavities, which caused occasional cavity quenches during input power rise. Cavity TW1AES001 eventually reached surface magnetic field of 70 mT in accelerating mode, limited by quench. Cavity TW1AES002 reached surface magnetic field of 95 mT in accelerating mode. Waveguide mode of cavity TW1AES002 was also investigated. The surface magnetic field reached 114 mT. During the power rise for waveguide mode, multipacting was present at all field levels, but was processed away in 30 minutes before the cavity reached quench field. Figure 4 and 5 showed the surface fields for both cavities in comparison to similarly processed TESLA 1-cell cavities.

For both cavities, the above background x-ray was not detected once the multipacting was processed away.

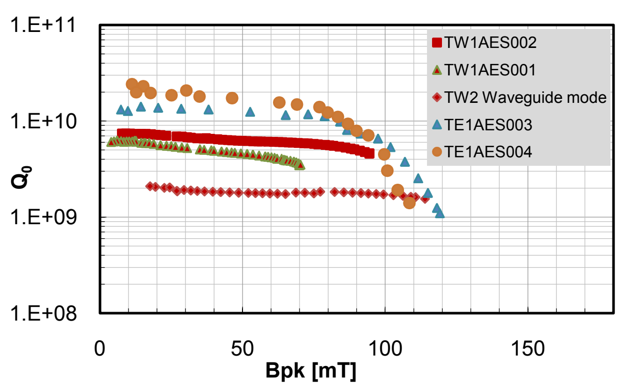

Figure 4: Surface magnetic field in comparison to TW1AES001, TE1AES003 and TE1AES004.

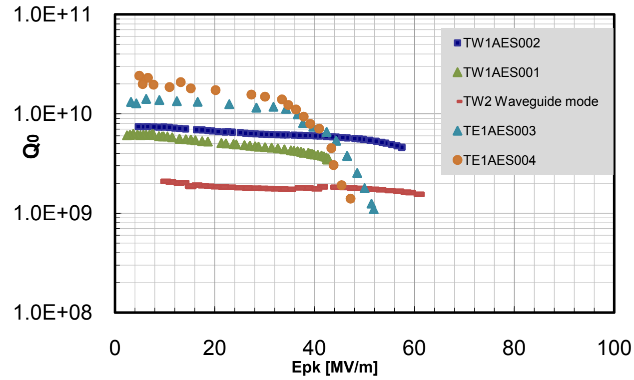

Figure 5: Surface electric field in comparison to TW1AES001, TE1AES003 and TE1AES004.

16 cernox temperature sensors were attached evenly around equator of cavity TW1AES002. In addition, 8 cernox sensors were attached to the high magnetic field region with four sensors at each side of waveguide. Initial result showed the maximum temperature rise of those temperature sensors on equator was no more than 0.1 K and no significant temperature rise was recorded on waveguide in accelerating mode. This suggested the quench was not near equator in the cavity cell, nor in the waveguide. Another high magnetic field region is the iris between waveguide and cell. Unfortunately, the area is not accessible by thermometers.

Residual resistance was measured for both 1-cell cavities, which was 19.4 nΩ for TW1AES001 and 18.3 nΩ for TW1AES002. The high residual resistance was caused by field leakage to the stainless steel end flanges at both beam pipes. This was separately verified by computation.

CONCLUSIONS

Surface electric field in Figure 5 suggested TW1AES002 reached equivalent 31 MV/m of TESLA shape cavity, with no field emission. That concludes both cavities were rinsed well and assembled well despite of the complex waveguide structure. The challenges for water residual in the cavity caused only procedural difficulty but likely not performance limitations.

T-map data (TW1AES002) indicated the quench is likely not in the cavity cell, which suggested additional chemical polishing such as electropolishing would greatly improve the performance.

The surface magnetic field is nearly comparable to the similarly processed (BCP) TESLA shape single cells.

REFERENCES

[1] P. Avrakhov, A. Kanareykin, S. Kazakov, N. Solyak, and V. Yakovlev "The Development of a Superconducting Traveling Wave Accelerating Cavity with High Gradient" Physics of Particles and Nuclei Letters, 2008, Vol. 5, No. 7, pp. 597–600