Performance of a High RRR Russian Nb 1.3 GHz TESLA Multicell Cavity*

T. Hays, P. Barnes, H. Padamsee, and J. Sears
Laboratory of Nuclear Studies, Cornell University, Ithaca, NY 14853, USA

Abstract

A four cell cavity of the TESLA shape was fabricated from Russian sheet Nb with a starting RRR about 500. The high RRR, translating to a high thermal conductivity, is sought to avoid thermal breakdown. Through high peak power pulsed processing (HPP) the cavity was able to reach a CW accelerating gradient of 18 MV/m before the thermal breakdown limit was reached. The cavity was then post purified by solid state gettering with Ti at 1350°C to double its RRR. A measurement following HPP of this post purified cavity yielded a CW accelerating gradient of 25 MV/m before a thermal breakdown.

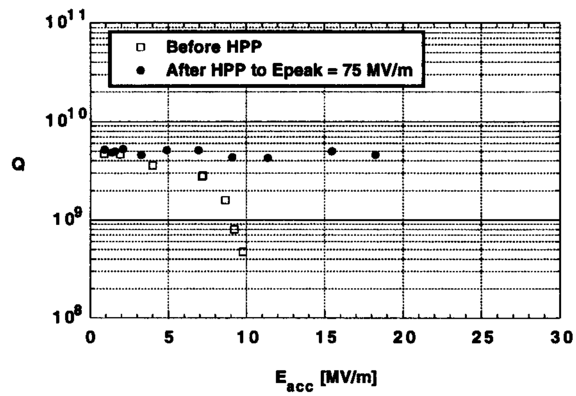

Figure 1: CW measurement of the performance of a RRR = 500 Nb 4 cell before heat treatment. After HPP, thermal breakdown limited the cavity to E_{acc} = 18 MV/m.

Cavity Tests

A four cell cavity of high RRR niobium was fabricated in an attempt to reach record accelerating field levels in an L-band multicell. The sheet material that was deep drawn and electron beam welded had a starting RRR of 500, the highest RRR material currently available. This is to provide the best thermal conductivity prior to heat treatment. A high thermal conductivity is used to push back the thermal breakdown limit. This limit could be present due to Ohmic heating from the global RF surface resistance but it is more likely to be dominated by heating at a thermal defect.

After fabrication, the cavity surface was prepared using our standard buffered chemical polish (1:1:2). This was followed by a low pressure ultra-pure water rinsing.

Cavity testing was performed on a vertical stand equipped for high peak power pulsed processing (HPP) at 2 MW for up to 270 μsec.

Figure 1 shows the results of the first test of the cavity before heat treatment. With HPP up to a peak surface electric field of 75 MV/m (E_{acc} = 39MV/m), the cavity was able to achieve a flat Q versus E curve until the cavity broke down thermally at E_{acc} = 18 MV/m.

Figure 2 shows the cavity's performance after it was heat treated for 3 hours at 1350°C with titanium

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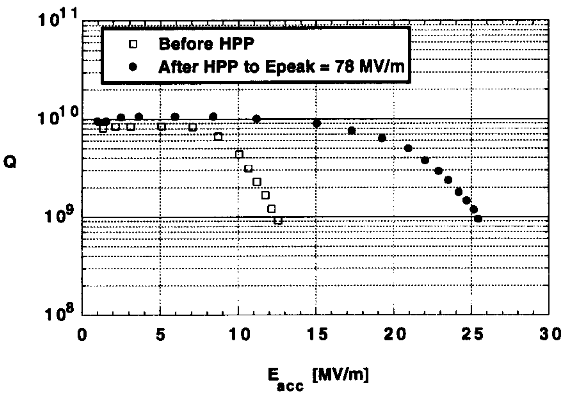

Figure 2: CW measurement of the performance of a RRR = 1000 Nb 4 cell after heat treatment. After HPP, thermal breakdown limited the cavity to E_{acc} = 25 MV/m.

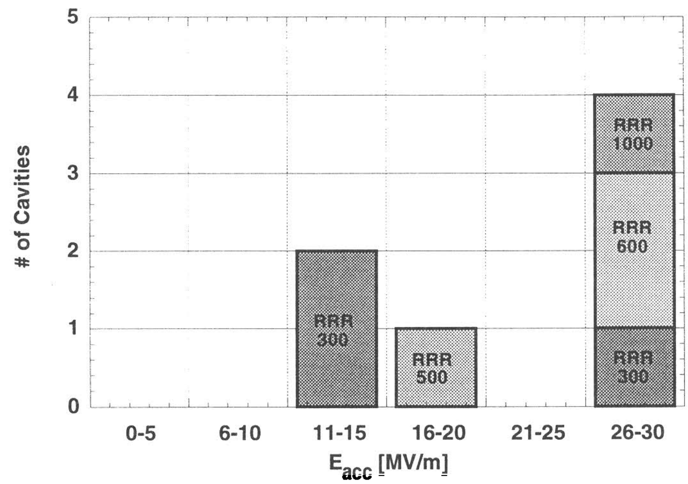

Figure 3: Summary graph of recent 4 and 5 cell Nb 1.3 GHz cavity measurements at Cornell.

as a getter inside and outside of the cavity. Following the heat treatment, the cavity received an acid etch by total immersion removing only 13 μm of surface material. The goal is to remove the titanium that was evaporated onto the cavity surface. This was followed by an inside-only etch resulting in a total inside surface removal of 70 μm. Again HPP was used to clean up the field emission. The presence of thermal breakdown limited the peak surface electric field reachable during HPP to 78 MV/m. The CW thermal breakdown limit was measured to be E_{acc} = 25 MV/m after the heat treatment.

The results of recent measurements of 4 and 5 cell TESLA shaped cavities is presented in Figure 3. Given the small statistics, it is ambiguous if the improved RRR of this cavity offered any advantage over the previous cavities. The variation of the thermal defects in each cavity spreads the statitics out a fair amount. Notice that one of the 300 RRR cavities reached E_{acc} of 27 MV/m without heat treatment.

Conclusions

Improving the thermal conductivity through post purification has in the past shown to yield higher accelerating gradients in Nb, but starting with material of 500 RRR instead of 300 has not yet clearly shown its worth.

Future measurements will be done on this cavity following more etching of the cavity surface. The first outside etch was lighter than desired. It is suspected that some Ti left on the outside is reducing the net thermal conductivity.