E mail

Hasan
I looked up some past results for the quench improvement with titanisation in case we want to consider HT 1300 C for one of the AES quenching cavities. The DESY/Zanon results need to be checked by the DESY experts of course

1) Cornell 5-cell, 1.3 GHz cavity #1 limited by quench at 12.5 MV/m improved by titanisation to 19 MV/m and after more etching to to 28 MV/m, limited by Q-slope + FE.

References: See 6th SRF workshop (CEBAF) p. 539, Q vs E curve before titanisation and epac94 paper attached, after titanisation and HPP.

2) Cornell 5-cell cavity # 3, 1.3 GHz, limited by quench at 13. 5 MV/m and improved by titanisation to 27 MV/m,
Reference: see p. 303 of Book: RF Superconductivity for Accelerators..Before/after titanisation

3) Cornell, 4-cell cavity, 1.3 GHz, thermal breakdown field improved from 18 MV/m to 25 MV/m after postpurification..
Reference: 7th SRF Workshop (Saclay) attached paper

4) Zanon, DESY 9-cell cavities 82, 83, 84
Lutz report at the TTC Frascatti TB (Dec. 2005) meeting (slide 10) that these cavities had weld problems and that "none of these cavities achieves a gradient above 28 MV/m without titanisation...
T maps show quenches on the equator"

I dont have the actual results before titanisation..

Matthias helped me find some test results in the data base (if he did it correctly)
Nov. 25, 2005 that Z82 reached 30 MV/m
Nov. 05 , 2005 Z83 reached 35 MV/m

I presume the above tests are after titanisation since gradients are above 28 MV/m?

Axel
Concerning Hasan´s data: there are two different stories on the 1400 C annealing

1) Improvement of thermal conductivity which give about 3-5MV/m
That's why we did it on all BCP cavities
2) Diffusion of material which sometimes gives more than this. Any defect

(oxides cluster of material or local impurities) that can diffuse at 1400 C will lead to larger improvements

Comment on
4) Zanon, DESY 9-cell cavities 82, 83, 84
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that these cavities had weld problems and that "none of these
cavities achieves a gradient above 28 MV/m without titanisation... T maps show quenches on the equator"

These cavities were limited at the equator welds, that's right. But in addition they showed QW disease. The results before 1400C may be influenced by this, so the improvement by 1400 C is a sum of homogenising the defect, improving thermal conductance and removing of H2 contamination and additional 100 µm material removals.

Actually we have Z 110 and Z111 that are limited by quench at equator welds as well. They do not have Q disease and got 1400 C treatments now. They are on the way to be measured (within the next 2-3 weeks) so we get well defined data points on that.

My Option
According to my knowledge the best and I think only chance to improve the AES cavities is the 1400 C heat treatment.

<u>Helen</u>
What I get from the DESY db is
Z82 went from 23 to 30 but with only 800 , Q disease cured. At 30 limited by power.
Z83 went from 24-5 to 34.5 with 1350. Limit breakdown
Z84 went from 27.8 to 22.9 after 1350 , with Q disease. limit power, Q 2.5e9
So....

<u>Detlef</u>
i) Together with Hans we agreed that a 1400C firing on the AES cavities is possible at DESY, if required. As our chem facilities work to max. capacity and Axel's man power is very limited any chemistry on these cavities is not possible. The cavities should be send as clean as possible.

ii) As a rough summary of Ti gain:
For BCP cavities the gain of 1400C treatment is about 5 MV/m in average, but with some spread.
For EP cavities data are very limited and I do dare to make any forecast.

Effect of Ti treatment:

- At 1400C all gases are more less free to move in the Nb. Therefore gaseous clusters are homogenized resulting in a homogenized thermal conductivity.
- By the reduction of the oxygen in the Nb the thermal conductivity is enhanced; typically to RRR about 500-600 in our furnce for pure Nb.

iii) As the cavities typically are limited by "local" defects (whatever these are), the global heating limit does not give any relevant information. Helen, you are right. Already with an RRR of 250-300 the global limit is at the theoretical limit (>180/200 mT) at 1.3Ghz.

For 3.9 GHz some computations are necessary. There is a rough approximation formula for big defects (see Hasan's book) without any frequency dependance (if I remember correctly..). In the defect free case the BCS losses increase with f^2 and and at some higher frequency the global thermal limit is below the Hc limit. According to the old Wuppertal computations at 3 GHz Hc can be achieved. I believe Hasan has a different opinion.

iv) To my personal point of view T-mapping is a MUST on the cavities. Without it you can discuss a lot and 1400C my improve the cavities, but you will not learn more.

Helen/ Kenji
Next week we are having a meeting at JLab to discuss the AES cavities (Agenda attached).
We still do not have much data on where the quenches are occuring - on or not on equater welds- but it seems likely we will proceed with Ti oven processing.

It occures to me that mechanical polishing of the welds might be considered also. Do you think that would be a good or bad idea?

It is quite good idea. We have to care for the equator EBW seam, which often brings EBW defects and magnetic field enhancement in case of large steps at the grain boundary on EBW seam. Mechanical grinding is a very powerful method to remove them.

What would mechanical polishing actually bring that more ep would not? Maybe of value if the welds look funny visually?

As you know, the finished surface roughness by EP depends on the initial roughness. Centrifugal barrel polishing can finish the surface with ~ 2 micron roughness. When the initial roughness is 2 micron, EP of 50 micron is enough to reach the surface smoother than 1 micron. By my understanding, no magnetic field enhancement happens if the surface roughness is less than 1 micron.
KEK is now testing to see that we can reduce the amount of EP when we have CBP before EP. We have one good result(single cell cavity), which shows Eacc 50MV/m by 40 micron EP after CBP.

We will continue this experiment.

Maybe you could say if you think there is anything good to be learned from mechanical polish.?

We have a history to use mechanical grinding since TRISTAN. If compare the result with other lab results, TRISTAN cavity has smaller scatter, but the gradient is only 10MV/m.
Now I would like to know the benefit of the mechanical grinding. KEK will test about this with single cell cavities.

And what you think is the best future treatment of these cavities limited at ~18MV/m

This is strongly related to mutipacting at the equator. The sulphur contamination during EP could cases the multipacting. The degreasing after EP is helpful against this problem.The probability of occurrence of the multipacting is reduced half but still there. The rinsing method could be poor. We are developing a stirring the detergent during degreasing.
Mabe EP+Degreasing(2%)+HPR+Bake could be best way.