MULTIPACTING IN 9-CELL TESLA CAVITIES

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Abstract

The recent multipacting observations for 9-cell Tesla cavities are presented. Investigated cavities were prepared by BCP (buffered chemical polishing) or EP (electropolishing) after 800 C or 1350 C furnace treatment. An influence of low temperature heat treatment (120-140 C) on multipacting process for EP cavities is analysed. An attempt to correlate multipacting in 9-cell Tesla cavities with method of preparation, a chemical and thermal treatment is done.

INTRODUCTION

Experimental results of multipacting (MP) in 9-cell Tesla cavities are presented for cavities prepared generally in two basic ways: buffered chemical polishing (BCP) and electropolishing (EP). All cavities were investigated in several vertical tests during last year. Totally 17 cavities were measured. All 8 BCP treated cavities were measured after high temperature heat treatment at 1350 C. 3 out of 9 EP cavities were tested only after 800 C heat treatment, the others after 1350 C heat treatment before EP. All tests were done in vertical cryostat in continuos wave mode at temperature 2 K. The standard procedure of BCP cavity preparation before first vertical test was usually as follows:

- degreasing and pure water cleaning
- BCP inside and outside
- heat treatment at 800 C for hydrogen and stress removal
- again degreasing and rinsing
- heat treatment at 1350 C combined with titanisation
- removal of Ti by BCP etching
- tuning of field profile
- final BCP of the inner side of cavity
- high pressure rinsing (HPR)
- assembly of all flanges
- final HPR.

Detail descriptions of the applied procedures for Tesla cavities preparation are shown in [1] and [2]. Similar procedures are also applied for EP cavities, but no BCP is done after EP.

In order to check the possibility to achieve high gradient, high Q performance for Tesla cavities only after 800 C heat treatment, some experiments for EP cavities were performed.

Although multipacting seems not to be now a major limitation for superconducting cavities, but still is important to investigate and understand this phenomena.

Some experimental observations [3] and theoretical simulations [4,5] were already done, but not all phenomena in performance of superconducting cavities can be satisfactory explained [6].

EXPERIMENTAL RESULTS

Two basic series of cavities were measured: BCP and EP after different heat treatments. For some EP cavities also influence of low temperature heat treatment (120-140 C) on their performance was investigated. Additionally, some experiments were done with cavities warm up above critical temperature and cool down again for the investigations of the frozen flux [3] and hydrogen Q disease [7,8] effects.

MP in BCP Cavities

Cavities after BCP treatment showed in general no MP. Investigated cavities are shown in Table 1.

Table 1: MP data for BCP treated cavities, where FE means field emission.

Cavity	**Test**	**Heat treatment**	**MP**	**FE**
AC58	1	1350 C	No	High
AC69	6	1350 C	No	High
C47	3 4 5	1350 C	Yes No Yes	High Low High
D39	4 5	1350 C	No No	High High
D41	3	1350 C	No	Low
Z49	6 7	1350 C	No Yes	High No
Z53	5 6	1350 C	No No	Yes No
Z54	4	1350 C	No	Yes

As one can see from this table, only for cavities Z49 and C47 MP was found, for the last one combined with high FE. Multipacting occurred for this cavities in the field range typically 15-21 MV/m and could be easily processed away within few minutes.

MP in EP Cavities

It was reported [3] that EP cavities may be more sensitive to MP. We measured 9 cavities electropolished at KEK. All 3 cavities after only 800 C heat treatment before EP showed MP, sometimes induced by low temperature bakeout. For 6 measured cavities heated at 1350 C before EP, MP was found in 3 cavities. Data for these cavities are collected in Table 2:

Table 2: MP in 9-cell EP Tesla cavities

Cavity	Test	Heat treatment	MP	FE
AC70	3	800 C	Yes	High
	4		Yes	High
	5		Yes	High
AC71	3	800 C	Yes	Low
	4	128 C	Yes	Low
AC72	6	1350 C	Yes	Low
AC73	1	1350 C	No	Low
	2	128 C	Yes	Low
AC74	4	1350 C	No	Low
	5	137 C	No	Low
AC75	1	1350 C	No	Low
	2		No	Low
	3		No	Low
AC76	1	800 C	No	High
	2		No	High
	3		No	No
	4	120 C	Yes	No
	5		Yes	Low
	6		Yes	Low
AC78	2	1350 C	No	Low
	3		No	High
	4		No	Low
	5		No	Low
	6		No	Low
	7		No	No
	8		No	Low
S35	6	1350 C	No	No
	7		No	Low

Typical example of excitation curve for cavity without MP is presented in Figure 1:

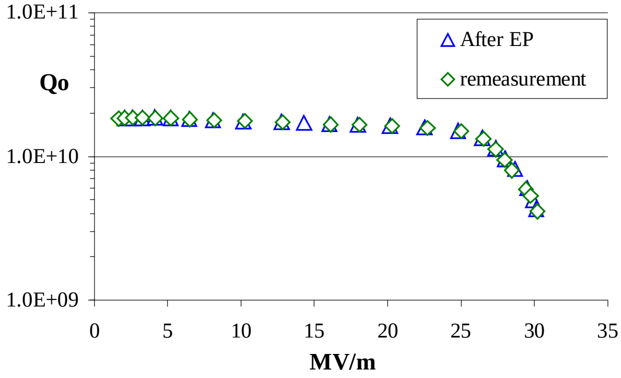

Figure 1: Excitation curve for Cavity AC76 in test 1. No MP is observed, although Q slope at field above 25 MV/m is clearly seen.

In order to improve Q slope observed at high field [6,9], low temperature heat treatment at 120 C was done to this cavity. As one could expect, Q was substantially better after this bakeout, but additionally strong MP was induced in this cavity. MP started at about 17 MV/m and was completed at about 20 MV/m after long 120 min processing. After first processing no more MP was observed in next measurements, but lost of the Q caused by MP was preserved also at low field, as one can see in Figure 2. This Q degradation is caused by frozen flux effect [3].

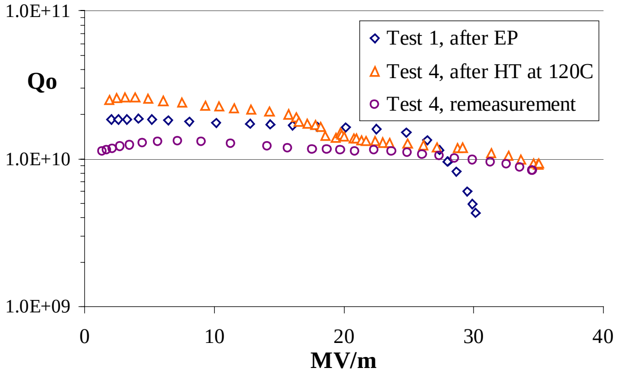

Figure 2: Behaviour of the cavity AC76 after bakeout at 120 C. No FE was detected during this measurement.

In order to investigate a Q disease effect [7,8] in this cavity, we warmed it up to 120-140 K. Cavity was kept at these temperatures for 90 hours and cooled down again to 2 K. Results are shown in Figure 3.

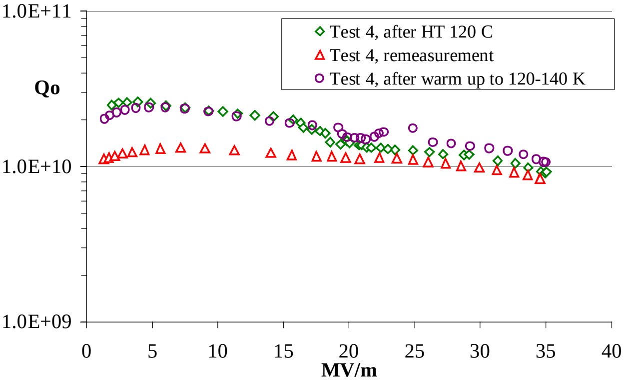

Figure 3: Behaviour of the cavity AC76 after warm up to 120-140 C and cool down again.

No Q disease was found for this cavity as one can see in Figure 3. Cavity again recovered to high starting Q value like direct after bakeout at 120 C. At about 20 MV/m processing events were found in the measurement after warm up and cool down. Recovery of the Q value after warm up above superconducting critical temperature supports hypothesis of frozen flux effect as responsible for Q degradation.

Similar behaviour of cavity performance was found for cavity AC73, which was before EP heat treated at 1350 C. No MP was observed for this cavity before bakeout at 128 C. After this low temperature heat treatment induction of MP between 18-21 MV/m was found and time necessary to process the cavity was about 15 minutes. The same recovery of the Q value after warm up this time to 15 K was also found for this cavity (see Figure 4).

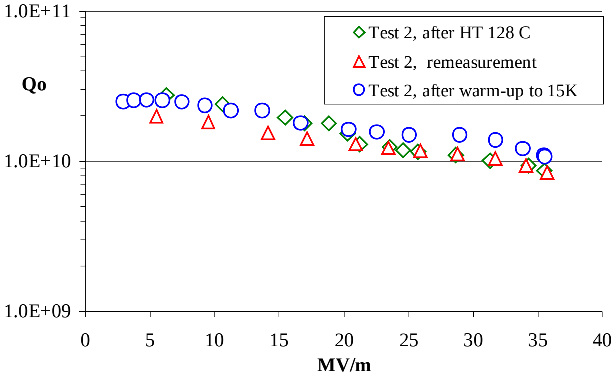

Figure 4: Behaviour of the cavity AC73 after HT at 128 C, warm up to 15 K and cool down again.

CONCLUSIONS

For BCP cavities there was practically no MP observed.

For EP cavities, which were heat treated at 800 C before EP, multipacting was found for all investigated cavities, sometimes combined with high field emission.

Only part of EP cavities after 1350 C heat treatment showed MP, sometimes induced by low temperature bakeout. In such cases processing time to pass through multipacting barrier was significantly longer.

There is no clear correlation between heat treatments and multipacting phenomena in investigated cavities. Multipacting in 9-cell Tesla cavities is strongly determined by conditions of cavity preparation and may be induced by low temperature heat treatment. During processing Q degradation was observed in some cases. This may be cured by warming up the cavity above the superconducting critical temperature.

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