EXPERIMENTAL COMPARISON AT KEK OF HIGH GRADIENT PERFORMANCE OF DIFFERENT SINGLE CELL SUPERCONDUCTING CAVITY DESIGNS

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Abstract

We have performed a series of vertical tests of three different designs of single cell Niobium superconducting cavities at 2 degrees Kelvin. These tests aimed at establishing that an accelerating gradient of 45 MV/m could be reached in any of the designs, while using the standard KEK surface preparation. The designs tested were the Cornel re-entrant shape (RE), the DESY/KEK Low Loss shape (LL), and the KEK ICHIRO series. The cavities underwent surface preparation consisting of centrifugal barrel polishing, light chemical polishing, electropolishing, and final a high-pressure water rinse. All three kinds cavities were used in a series of vertical tests to investigate details of the surface treatment. When using ultra-pure water for the high pressure rinse, the LL cavity reproducibly exceeded a gradient of 45 MV/m, the RE design reproducibly reached a gradient of between 50 MV/m and 52 MV/m, and three of the six ICHIRO cavities reached a gradient of between 45 MV/m and 51 MV/m.

INTRODUCTION

High pressure rinsing (HPR) with ultra-pure water has brought a breakthrough with the niobium superconducting RF cavity, however, the gradient seems to be saturated around 40 MV/m. The question is in still technical limit or fundamental limitation due to niobium material. A thesis of the fundamental limit was proposed by K.Saito [1]. He estimated the critical field H_{CR} is around 1750 ±150 Oe (Fig.1). The TESLA cavity shape has a 42.6 Oe/[MV/m] of Hp/Eacc ratio. It corresponds to 41MV/m. He proposed to use a new cavity design with a lower Hp/Eacc ratio, then still ~50MV/m would be possible even under the magnetic RF limitation [2]. We have made a study to verify his thesis, using three different cavity shapes; Low loss (LL), Reentrant (RE), and ICHIRO shape (IS). This paper presents a new breakthrough of 50MV/m by these new shapes.

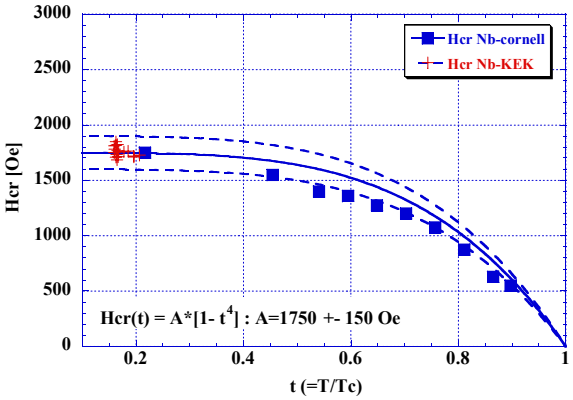

Fig. 1: Fitting results of the experimental RF critical field.

CAVITY DESING

Three cavities with low Hp/Eacc were fabricated; RE by Cornell [3], LL by DESY [4], and IS by KEK/DESY in principle LL. The comparison of the shape is shown in Fig. 2. Cavity RF parameters are summarized in Table 1. Since RE and LL shape have a 15% lower in Hp/Eacc ratio than that of TESLA one, it is expected a higher gradient of 47-53MV/m.

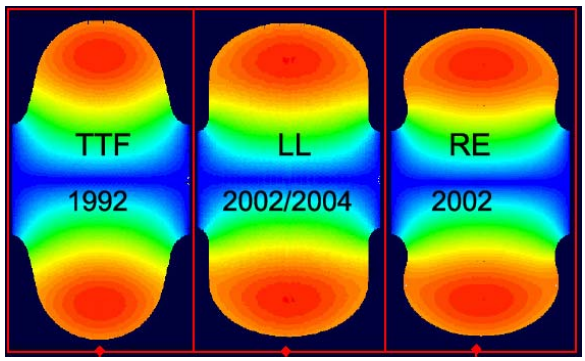

Fig. 2: Comparison of single cell shapes.

Table 1: Cavity RF parameters.

	TESLA	LL	RE	IS
Diameter [mm]	70	60	60	61
Ep/Eacc	2.0	2.36	2.21	2.02
Hp/Eacc [Oe/MV/m]	42.6	36.1	37.6	35.6
R/Q [W]	113.8	133.7	126.8	138
Γ [W]	271	284	277	285
Eacc max [MV/m]	41.1	48.5	46.5	49.2

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