RECENT DEVELOPMENTS IN THE CORNELL Nb_3Sn INITIATIVE*

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Abstract

Superconducting accelerator cavities coated with Nb_3Sn have already demonstrated significantly higher unloaded quality factors than standard niobium cavities at surface magnetic fields $<$ 30 mT. Theoretical predictions suggest that the maximum critical field of such cavities could be twice that of niobium cavities. Significant facilities have been developed at Cornell University to fabricate Nb_3Sn using the vapor diffusion technique. In this paper, recent progress is presented from our Nb_3Sn program. The first RF results from a test of a Nb_3Sn sample in a TE pillbox sample cavity are presented as well as first images of the newly constructed apparatus for coating full 1.3 GHz single cell cavities.

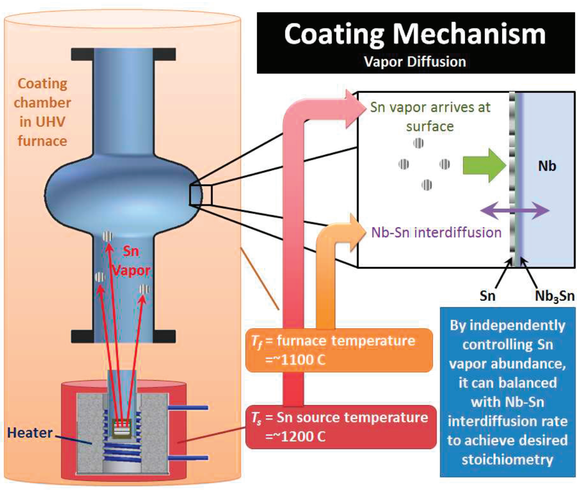

Figure 1: Illustration of the vapor diffusion coating method used at Cornell to coat Nb cavities and samples with Nb_3Sn.

INTRODUCTION

Increasing Q_0 at moderate accelerating gradients ~15 MV/m would substantially decrease in the load on the cryogenic plants of high energy CW SRF linac applications such as the Cornell and KEK ERLs and Project X. This would save millions of dollars in power and infrastructure costs. Tests of cavities coated with Nb_3Sn using the vapor diffusion method (illustrated in Fig. 1) have shown Q_0s of 10^{10} at 4.2 K and 10^{11} at 2 K, much higher than Nb [3]. These measurements were made at relatively low fields, as shown in Fig. 2, but this performance was very similar to that of Nb cavities at the time.

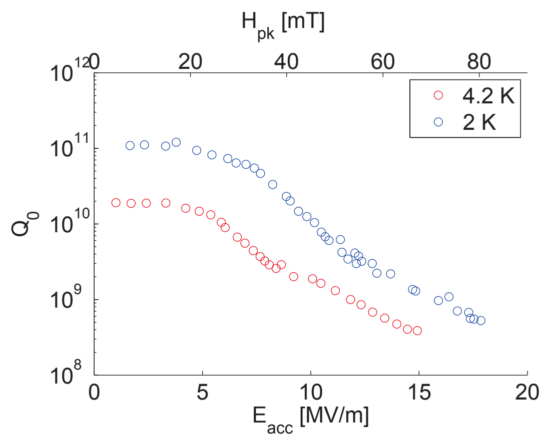

Figure 2: Q vs E curve of a 1.5 GHz Nb_3Sn coated cavity. Image adapted from [3] using data from Wuppertal and Jefferson Lab.

Surface preparation techniques developed since then may help to improve performance, so that the high Q_0s would persist up to moderate accelerating gradients. In addition to this, the superheating field of Nb_3Sn was calculated in a recent paper to be almost twice that of Nb [4]. This suggests that it may be possible, with investment in research and development, to use Nb_3Sn to reduce the length of high energy linacs.

PREPARATION

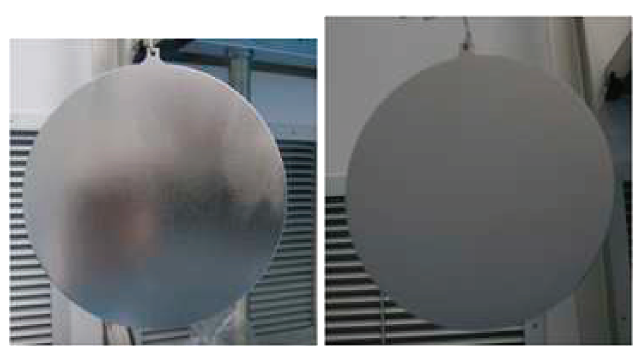

Figure 3: Nb Sample plate before (left) and after (right) Nb_3Sn coating

A 3.75-inch diameter niobium sample shown in Fig. 3

* Work supported by NSF Career award PHY-0841213, DOE award ER41628, and the Alfred P. Sloan Foundation
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was coated with Nb_3Sn for testing in Cornell's TE pillbox sample-testing cavity (shown in Fig. 4—see [2] for description of the cavity). Made from RRR 280 Nb, the sample was given a 130 μm BCP and HPR. Following this, it was mounted in the sample coating chamber and treated with a 1-day degas performed at 200 C to minimize potential RRR degradation. It then underwent the coating via vapor diffusion (approximately 12 hours). A witness sample coated with it showed the desired composition under EDX and under anodization. After another HPR, the sample was assembled in the TE pillbox cavity and a T-map system was assembled to the high field region of the sample.

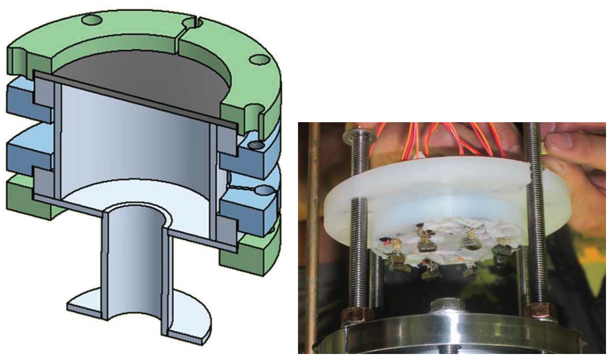

Figure 4: TE pillbox cavity which housed the sample plate (left) and T-map setup (right)

SLOW COOLDOWN

Previous tests of Nb_3Sn [1] indicate that temperature gradients over the surface of the cavity during cooldown create thermocurrents that caused increased R_s. A slow cool down was performed to avoid this, and the temperature gradient across the sample was measured using cernox sensors at the center and at the edge of the sample. The gradient did not exceed 0.2 K for the cooldown through the Nb_3Sn transition at approximately 18 K, as shown in Fig. 5.

RF RESULTS

The cavity with Nb_3Sn sample was tested at 1.6 K, where the T-map resistors have high sensitivity. Quench occurred at approximately same field level as the cavity with Nb sample. At this field, the peak magnetic field on the sample reached approximately 40 mT, showing that the sample is superconducting with relatively good RF properties.

The Q_0 of the Nb_3Sn sample cannot be measured directly with RF measurements as its performance cannot be decoupled from that of the Nb cavity walls. The copper input coupler has significant losses, further complicating the measurement. T-mapping did not yield a R_s measurement as the resistors were affected by direct heating from the RF (large ΔT with RF on, but not coupled to the cavity). As

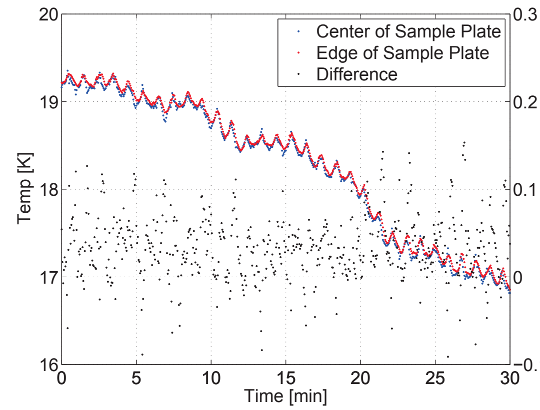

Figure 5: The sample was cooled slowly through the Nb_3Sn transition to avoid high residual resistance resulting from temperature gradient-induced thermocurrents. The difference in temperature between the center and at the edge of the sample was monitored using Cernox sensors.

a result, this is only a preliminary measurement, but initial indications from this first sample are optimistic.

CONCLUSIONS AND OUTLOOK

The first Nb_3Sn sample for RF testing produced at Cornell was tested in the Cornell TE pillbox cavity. Preliminary results are optimistic, showing that the sample is stable under magnetic fields of at least 40 mT. Due to suspected direct RF heating of the resistors, T-mapping did not yield a measurement of the R_s, but testing will continue so that this problem can be reduced and the performance can be measured accurately.

An apparatus for coating full single cell 1.3 GHz cavities, shown in Fig. 6 is about to begin calibration and commissioning. After coating single cell cavities, they will be tested with full T-map. Using the RF performance measured in these tests and the sample tests as feedback, the Nb_3Sn coating parameters will be optimized.

ACKNOWLEDGEMENTS

Special thanks to Andriy Ganshyn for his help with the helium system during cavity testing.

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ISBN 978-3-95450-115-1

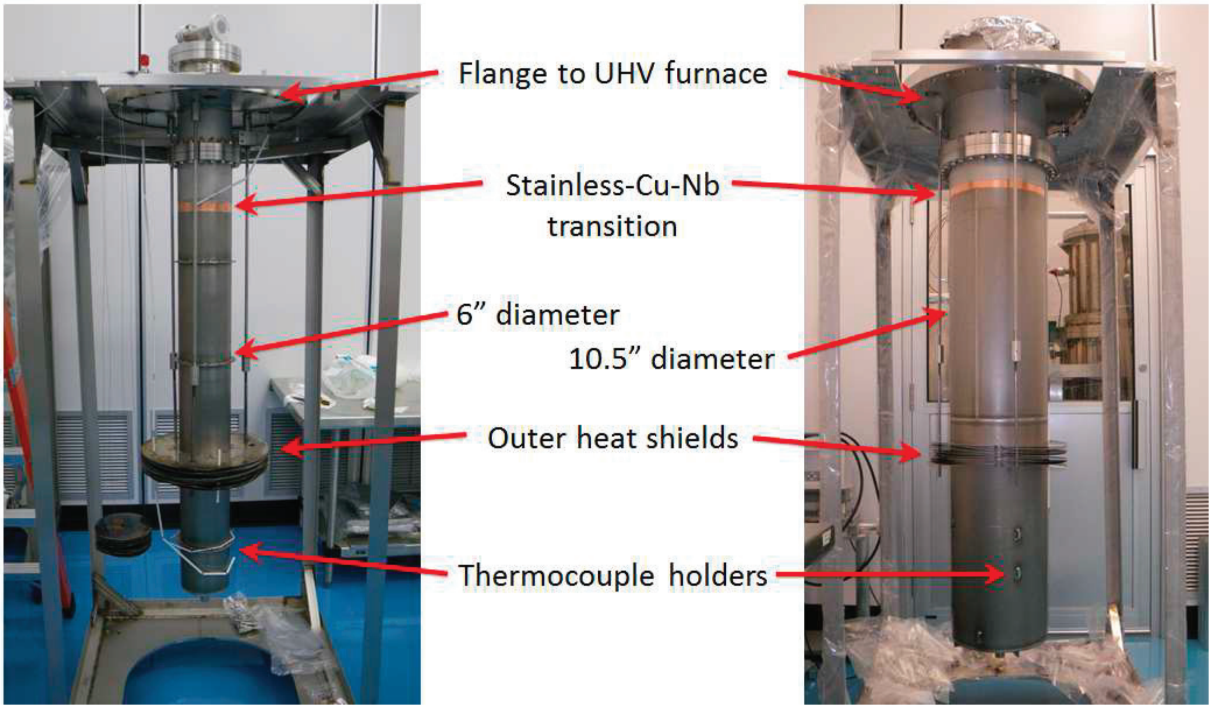

Figure 6: Apparatus used to coat samples (left) and new apparatus for full single cell cavities (right). They are designed to fit inside the UHV furnace in the Cornell SRF clean room.