15th International Conference on RF Superconductivity • July 25-29, 2011
Chicago, Illinois, USA

Cornell Laboratory for
Accelerator-based Sciences and Education (CLASSE)

Stoichiometric Nb_3Sn in First Samples Coated at Cornell

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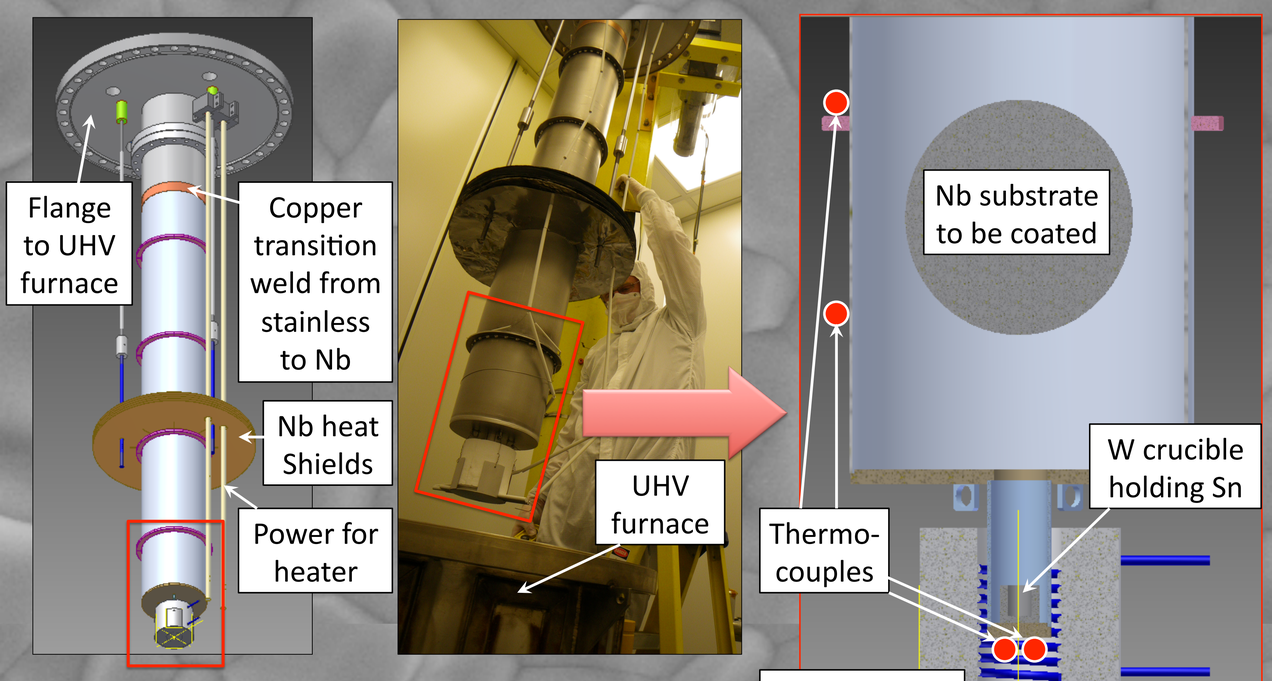
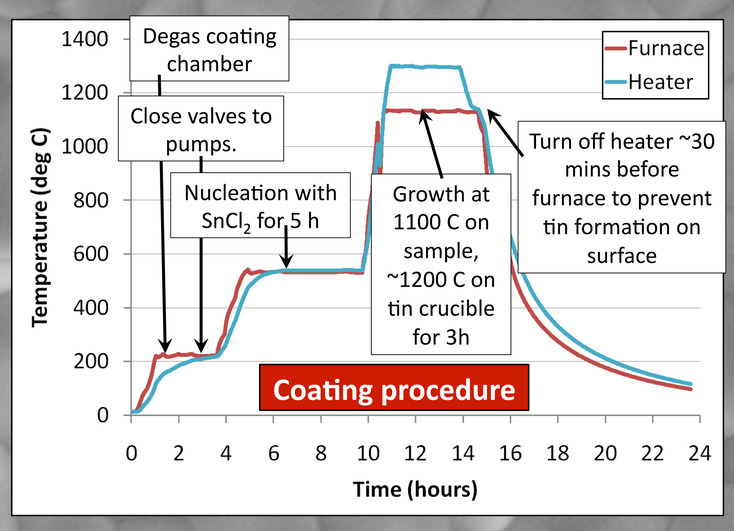
Introduction

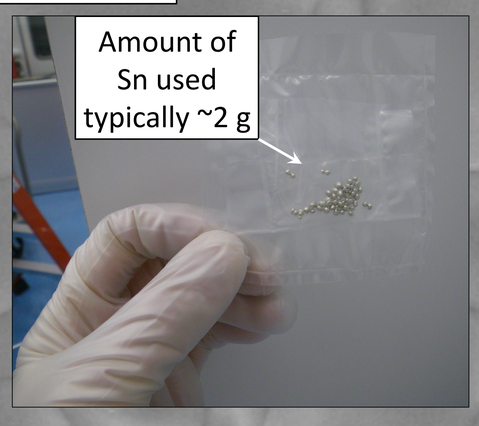
An SRF cavity coated with the superconductor Nb_3Sn theoretically will be able to reach more than twice the maximum accelerating field of Nb in a cavity under the same operating conditions and will have a much lower surface resistance at a given temperature. Previous research at the University of Wuppertal, CERN, Cornell, Jefferson Lab, and SLAC has produced promising results [1]. Combining the experience gained from these tests with new preparation techniques, it may be possible to obtain Q_0 values exceeding those of niobium at mid-field levels or even fabricate cavities able to withstand surface fields >200 mT.

Vapor Diffusion Coating

Nb3Sn coatings were applied to Nb substrates by evaporation of tin onto the Nb surface at temperatures exceeding 1100°C in a clean room UHV furnace. The coating chamber is a self-contained system that fits inside an existing furnace.

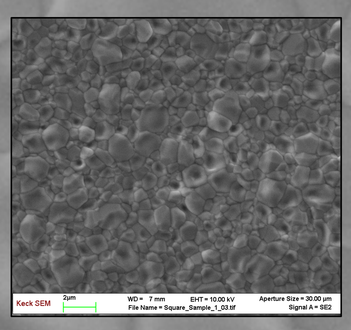




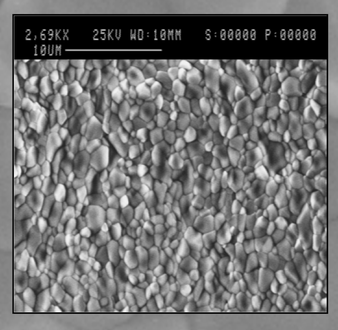


SEM Images and Anodization

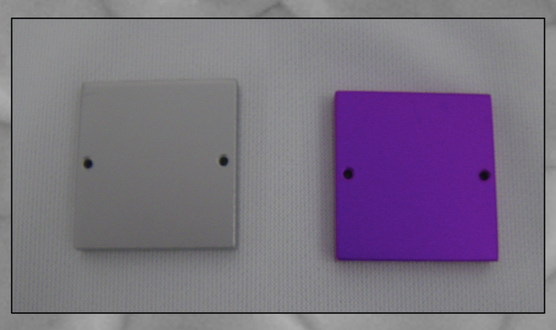
SEM images of first samples show micron-sized grain growth similar in appearance to images from Wuppertal. Anodization of sample at 75V in ammonium hydroxide yields pink-purple color characteristic of Nb3Sn.



Cornell, 2011



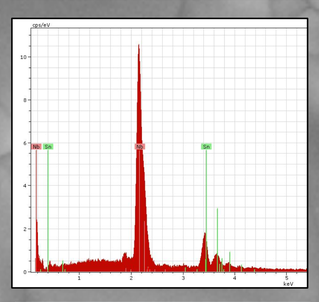
Wuppertal, 1996



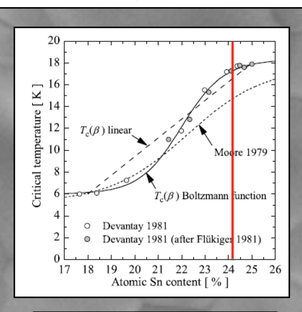
Not anodized | Anodized

X-Ray Analysis

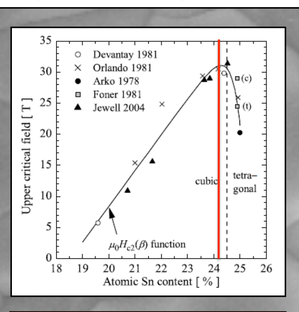
The samples underwent EDX analysis with a LEO 1550 FESEM. The analysis probes the elemental structure of the sample about 0.5-1.0 um into the surface. The samples were shown to have a composition of approximately 24.2 atm%Sn. From [2], this composition is in the range with the highest critical temperature and the highest upper critical field. XPS scans were also performed which show that the Nb3Sn layer has approximately uniform composition up to a depth of ~1.5 μm.



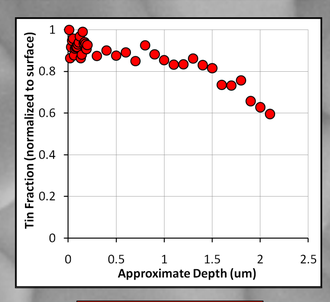
EDX Spectrum



T_c vs %Sn [2]



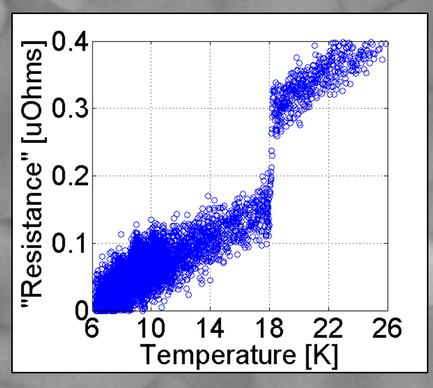
H_{c2} vs %Sn [2]

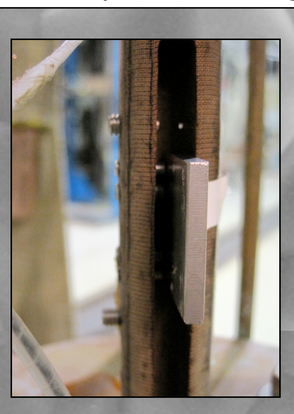


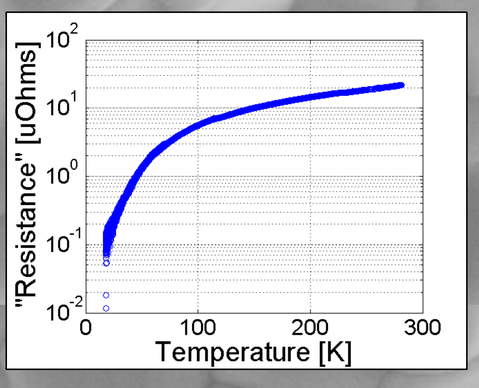
XPS Data

T_c and RRR

T_c ~18.1 K was recorded by 4 wire measurement, close to the highest recorded value for Nb_3Sn of 18.3 K [2]. Nb with RRR 280 was used for substrate. In the same 4-wire measurement, a lower bound for RRR after coating of 210 was established. It would be higher if normal resistance could be measured down to 4.2K. This shows that the coating process results in only minimal degradation of Nb substrate RRR.



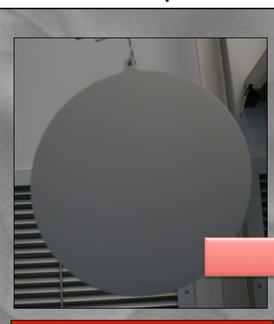




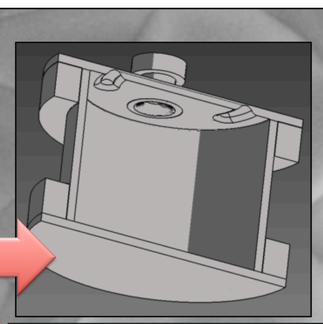
RF Test in TE Pillbox Cavity

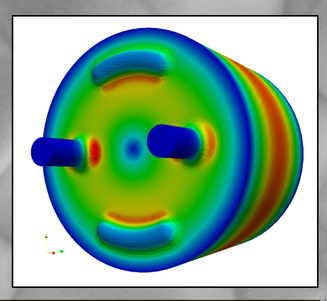
A Nb bottom plate for Cornell's TE pillbox cavity was coated with Nb_3Sn so that RF tests could be performed. It was made from RRR 280 Nb and received a 130 um BCP and HPR before coating. It received a 1-day degas before high temp. treatment. A small T-map has been developed for precise surface resistance measurement.

Before coating



After coating





Cavity bottom plate is Nb_3Sn-coated

Conclusions and Outlook

Very promising results have been obtained on the first samples produced by the Nb_3Sn program at Cornell. T_c measurements, EDX, and anodization all suggest that the desired composition has been achieved. The next step will be RF testing in the pillbox cavity. Fabrication of a full single cell cavity is planned for 2012.

References

[1] G. Müller et al. EPAC 1996. p. 2085.
[2] A. Godeke. Supercond. Sci. Technol. 19 R68. 2006.

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, and CHESS resources have merged and a new lab, (CLASSE), has formed. CLASSE develops and operates facilities and provides infrastructure for the study of beams and accelerators, photon science, particle physics and the early universe, serving students, the public and scientists from Cornell and elsewhere. LEPP's primary source of support is the National Science Foundation.