Radio Frequency Cavity for Tight Loop Optimization of Nb_3Sn Thin Films

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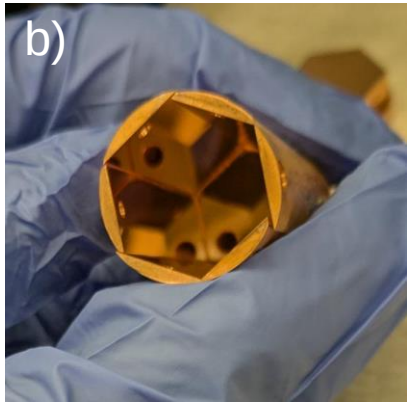
Traditionally, measuring the AC properties of conducting surfaces requires a complicated testing device incompatible with high magnetic fields. Here, we describe our compact 26mm diameter cavity that integrates AC testing with a modular set of removable samples in one device. The cavity resonator has six Cu walls that can be coated with a high-field superconducting material such as Nb_3Sn. Our present effort aims to test the quality factor (a measure of energy efficiency) of Nb_3Sn made by different recipes to optimize the material for quantum detectors. Even without a superconductor, our cavity attained a very good quality factor of 17,000 at 10GHz when operated at 77K. This research is part of a larger collaboration at Lawrence Livermore National Laboratory to detect dark matter in our universe.

Investing in testing devices and developing superior superconducting coatings has far-reaching implications beyond the physics of dark matter, with these optimized coatings, enhanced particle accelerators can be built with higher power and greater efficiency, significantly reducing the costs of operating major science facilities. These advancements also enable lower-cost, high-power electron, and ion beams for applications such as breaking down PFAs and microplastics, sterilizing medical equipment, detecting threatening materials, medical isotope production, and other industrial projects. Furthermore, this research advances our understanding of the material science and physics of superconductors, particularly their behavior under AC conditions and in high magnetic fields.

Figure 1(a). A view of the bare Cu cavity with one wall removed. In (b) the cap is lifted showing the internal resonator. The mirror finish is visible in both images.



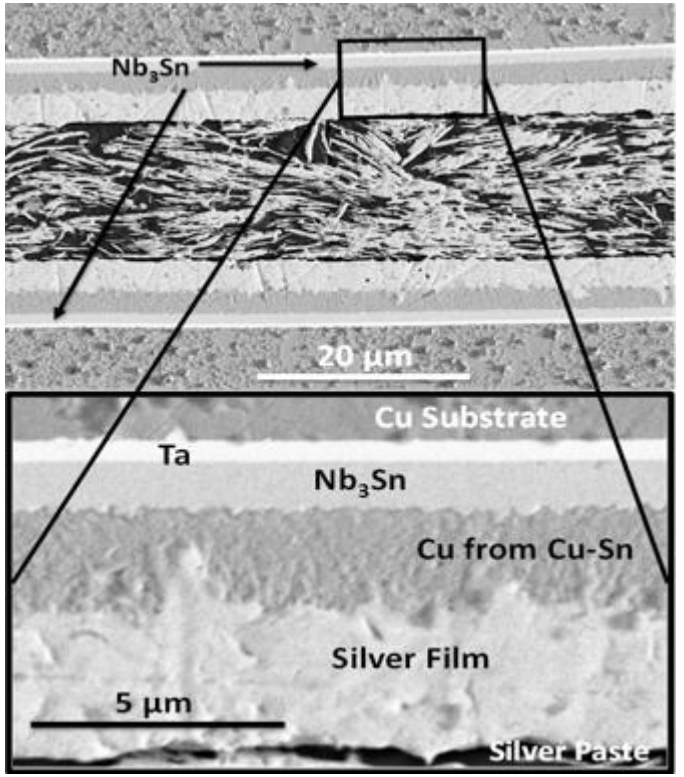


Figure 2. Nb_3Sn film deposited on copper with uniform microstructure for the detector cavity.

Facilities and instrumentation used: Applied Superconductivity Center – NHMFL, Vector Network analyzer at NHMFL and 9T PPMS at ASC
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