Nb_3Sn films via a novel hot-bronze method for compact accelerators

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Nb_3Sn coated Superconducting Radio Frequency (SRF) cavities could potentially operate at temperatures of 4K to 8K, which can be achieved by compact refrigerators. In principle, this new technology could provide low losses and high accelerating gradients without the need for expensive superfluid helium infrastructure. Intense electron beam and X-ray sources could thus become small and portable.

Present Nb_3Sn coating processes require special conditions including high temperature, ~1200°C, for direct reaction of Sn with a Nb cavity body. *New data suggest that Nb_3Sn can be more easily made by reaction of Nb with bronze, a Cu-Sn alloy. This process would take advantage of the simpler fabrication and high thermal conductivity of Cu cavity bodies*.

The MagLab's Applied Superconductivity Center is a pioneer in Nb_3Sn wire fabrication. This knowledge base was used to produce Nb_3Sn films on bronze and Cu substrates, resulting in the discovery that Nb deposited onto hot bronze at ~715°C instantly converts to Nb_3Sn and achieves a film growth rate 10x faster than Nb-bronze solid-state reactions. **Figure 1** compares this new hot bronze route with the conventional two-step post-reaction process. **Figure 2** contrasts the resulting grain morphologies. *The new hot bronze method produces improved grain structure and materials properties. Micro-chemical measurements suggest that the improved performance is due to a higher Sn:Nb ratio in the Nb_3Sn*. Future work seeks to raise the ~15K critical temperature that perhaps results from thermal contraction challenges.

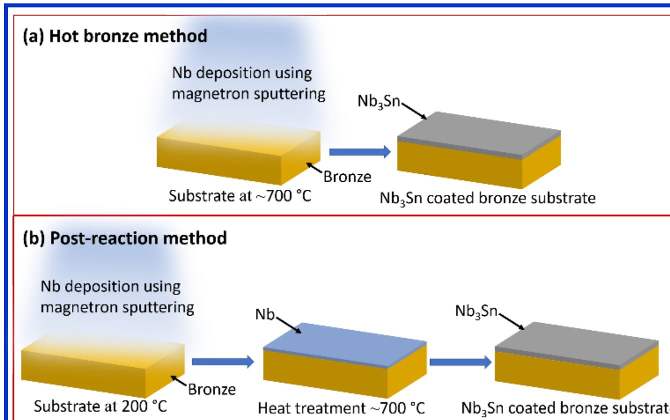

Fig 1. Comparing (a) the hot bronze method with (b) the post-reaction method. Both methods can be easily scaled to improve the performance of SRF cavities.

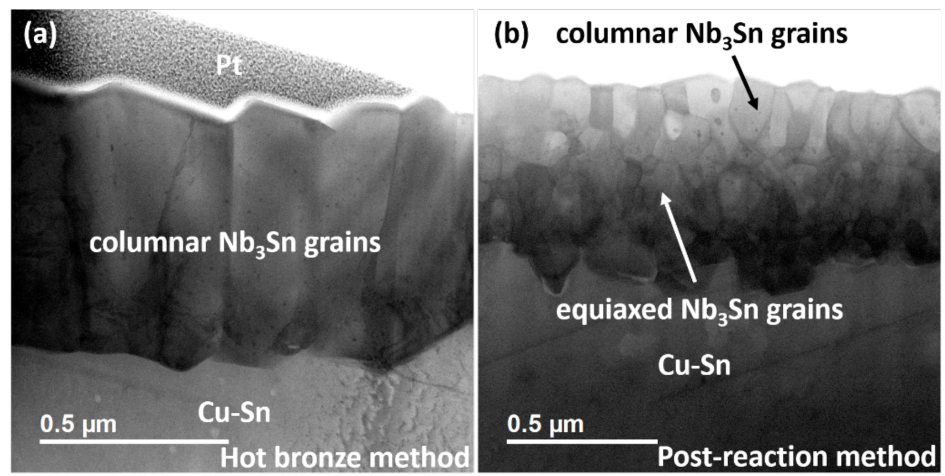

Fig 2. Bright field STEM cross-section images of Nb_3Sn films produced using (a) the newly-discovered hot bronze method and (b) the post-reaction method.

Facilities and instrumentation used: Applied Superconductivity Center, the JEOL-ARM TEM/STEM facility at the MagLab
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