Nb_3Sn wire fabrication using rod-in-tube method with a diffusion couple of Nb and Sn alloy with co-addition of Cu and Zn

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Abstract: Large-scale projects such as the next generation high energy particle accelerator project demands not only further J_c improvement of Nb_3Sn wires, but also cost performance. The cost performance is deeply related to the wire design and the drawability of wires. In the bronze process, the small Sn solubility in the Cu-Sn bronze results in a low Sn supply required for Nb_3Sn formation, leading to a small Nb_3Sn volume fraction and low Sn content in the Nb_3Sn phase. That strongly suppresses the performance of the Nb_3Sn wire. Therefore, in order to increase the Sn supply in the wire assembly and maximize the Nb_3Sn performance, we need to utilize internal-tin concept, where Sn cores are separated to Cu matrix in the precursor. This time, however, the hardness balance within the cross section becomes crucially unbalanced: the Vickers hardness of Nb and Cu after full annealing is ranging from 60 to 80, while that of Sn is approximately 10. This significant imbalance in hardness is one of the causes of reduced drawability of internal tin wire. Nb_3Sn wires can be also manufactured by powder-in-tube method. However, the drawability of wires is worse in general because good connectivity between powders cannot be ensured.

If the hardness of Sn core can be increased, the drawability of wire should be improved. Furthermore, if the diffusion couple of the single module can be constructed by Nb ring and Sn-alloy core without intermediate Cu layer, the manufacturing process will be simplified. Moreover, the reaction schedule will be able to be shortened because the Cu/Sn mixing stage can be eliminated. In this work, we prepared a special Sn alloy with co-addition of Cu and Zn. Then, the microstructure of Sn-Cu-Zn and the reaction behavior of the diffusion couple consisting of Nb and Sn-Cu-Zn are reported.

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