

§2. Development of New High Field and High Current Density Superconductors for Fusion Devices

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Nb₃Sn superconductors with improved high-field performance have been prepared by the Jelly Roll (JR) process using Sn-Ta based sheet.¹⁾ In this study, new JR-processed Nb₃Sn wires with Sn-B based sheet have been successfully fabricated. Then the structure and superconducting properties of Sn-Ta and Sn-B based sheet wires have been compared.

Sn-B based alloys with Sn/B atomic ratio of 4/1-8/1 were prepared by a reaction among constituent metal powders at 750°C. A small amount of Ti and Cu were added to the alloys. A tightly consolidated button was obtained, which was pressed to a plate, and then rolled into a sheet 80 μm in thickness. The sheet was laminated with a Nb sheet 100 μm in thickness, and wound into a JR composite. The composite was encased in a Nb-3.3at%Ta sheath, and drawn into a wire 1.4 mm in diameter. Finally the wires were heat treated at 725°C~770°C in vacuum.

The Ti in the alloy has a strong affinity against both B and Sn, and accumulates around B particles, which effectively improves the bonding between B particles and the Sn matrix. The Cu in the alloy decreases the reaction temperature to form Nb₃Sn layer from 900°C to 750°C. Thick Nb₃Sn layers with nearly stoichiometric Sn concentration are synthesized in the wire through the diffusion between the Sn-B based sheet and the Nb sheet. The Nb₃Sn layer is composed of nearly uniform and equiaxed grains. The Nb₃Sn layers formed in the JR wires using Sn-Ta and Sn-B based sheet show almost the same microstructure.

Fig. 1 summarizes the T_c transitions of JR wires and a commercial bronze (16wt%Sn+0.3wt%Ti) processed wire. The T_c transition of the bronze processed wire is onset 17.2K and offset 16.8K. The JR wires show offset T_c of ~18.1K with a transition width of less than 0.1K. Thus the JR wires indicate much higher and sharper T_c transition than the bronze processed wire. This may be attributed to the stoichiometric and uniform Sn concentration in the Nb₃Sn layers formed in the JR wires. The Sn-B based sheet wires show slightly higher T_c compared to the Sn-Ta based sheet wires.

Fig. 2 illustrates B_{c2} transitions of Sn-Ta and Sn-B based sheet JR wires at 4.2K. Both wires show nearly the same B_{c2} transition of onset 27.2T, midpoint 26.8T and offset

26.4T. T_c and B_{c2} (4.2K) values of JR processed wires are at the higher end of those in Nb₃Sn wires. The workability of the Sn-B based alloy is even better than that of the Sn-Ta based alloy. Present study has revealed that Sn-B based alloy is a promising new material for Nb₃Sn wire fabrication through the JR process.

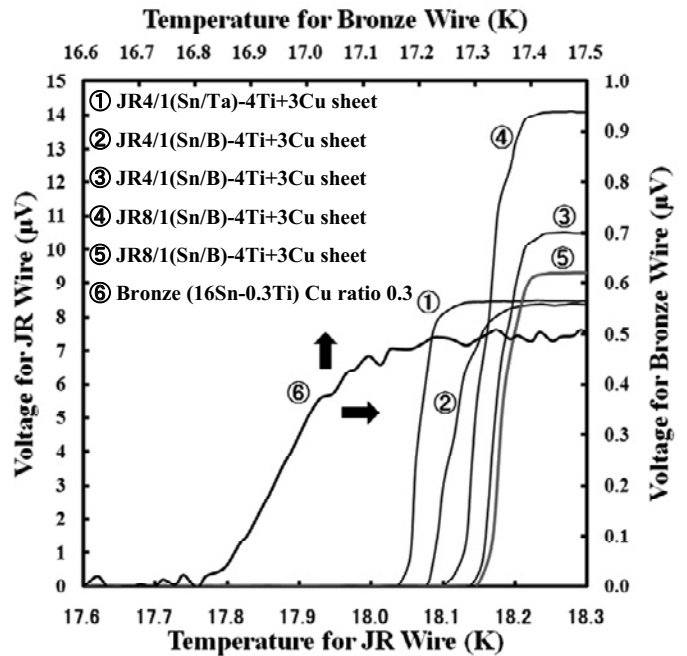


Fig.1 T_c transitions of JR wires with quoted sheet composition. The transition of a bronze processed wire is also indicated.

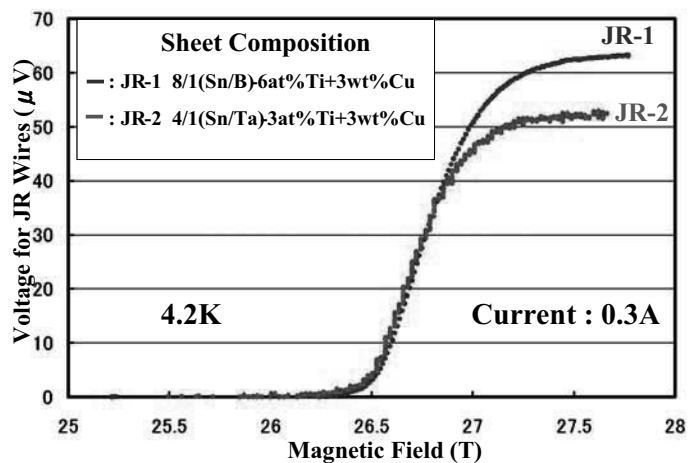


Fig.2 B_{c2} (4.2K) transitions of Sn-B and Sn-Ta based sheet JR wires.

1) Tachikawa, K. Tsuyuki, T. Hayashi, Y. Nakata, K. and Takeuchi, T.: Adv. Cryogenic Engineering (Material), Vol 54(2008)pp244-251