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

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$Nb_3Sn$ 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 $Nb_3Sn$ 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℃. 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 100μm 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 ㎜ in diameter. Finally the wires were heat treated at 725℃~770℃ 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 $Nb_3Sn$ layer from 900℃ to 750℃. Thick $Nb_3Sn$ 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 $Nb_3Sn$ layer is composed of nearly uniform and equiaxed grains. The $Nb_3Sn$ 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 $Nb_3Sn$ 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 $Nb_3Sn$ 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 $Nb_3Sn$ wire fabrication through the JR process.

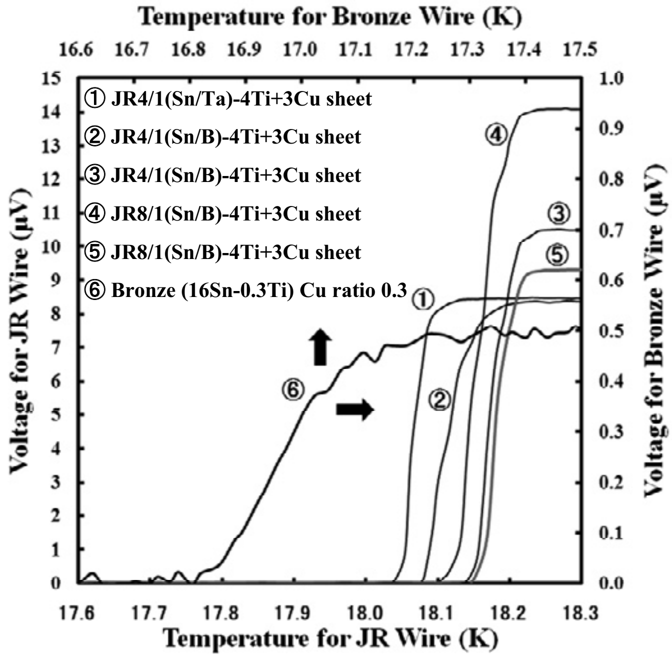


Fig.1 $T_c$ transitions of JR wires with quoted sheet composition. The transition of a bronze processed wire is also indicated.

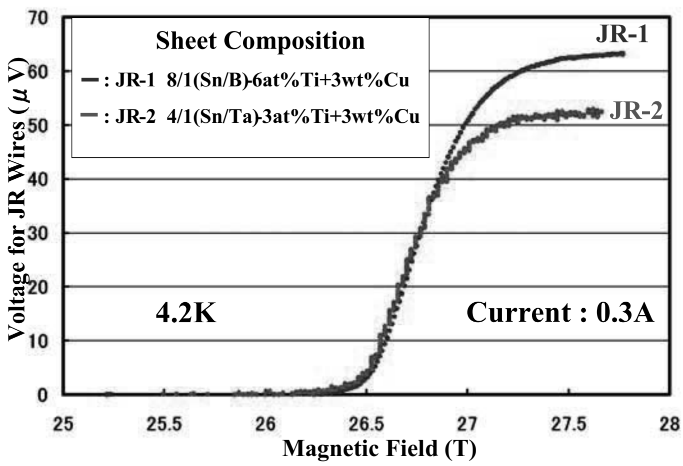


Fig.2 $B_{c2}$ (4.2K) transitions of Sn-B and Sn-Ta based sheet JR wires.

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