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

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New Nb_3Sn superconductors with improved high-field performance have been prepared by the Jelly Roll (JR) process using Sn-Ta based sheet. The wire shows a quite high B_{c2} (4.2K) of 26.9T(mid)[1]. In this study multirod (MR) wires are newly fabricated using Sn-Ta based rods.

The Sn-Ta based alloy was prepared by the reaction among constituent metal powers at ~770°C. The Sn/Ta atomic ratio is 4/1 in which 3at%Ti is substituted for Sn, and 3wt%Cu is added to the resulting powder. Tightly shrunk alloy is obtained after the reaction. The Sn-Ta based alloy was pressed into a rod, and encased in a Nb-3.3at% sheath with outer/inner diameter of 10.0/7.0mm. Then the composite was fabricated into a hexagonal wire with 1.22mm side-to-side distance. 19 or 37 elementary wires were lapped by a Nb sheet (barrier) and encased in a Cu jacket. The multirod composite was fabricated into a wire by hydrostatic extrusion and subsequent drawing at Hitachi Cable Ltd.. No intermediate annealing was required for the wire fabrication.

Fig. 1 is the EPMA composition mappings of the 37 rod MR processed wire. The Sn-Ta rods are fabricated uniformly in the wire. About 30μm thick Nb_3Sn layers are formed around Sn-Ta based rods. The Sn concentration in Nb_3Sn layers formed in the 37 rod MR wire is about 23at%, which is a little lower than that formed in the JR wire. The diffusion interface in the JR wire is flat, while that in the MR wire is round. This configuration difference may cause a slight difference of Sn concentration in Nb_3Sn layers. There is almost no gradient in Sn concentration throughout the Nb_3Sn layer formed in the MR wire as in the JR wire.

Both 19 rod and 37 rod MR wires show nearly the same B_{c2} (4.2K) value of 27.0T (on), 26.5T (mid) and 26.0T (off). This value is a little lower than that obtained in the JR wire. A slightly lower Sn concentration of the Nb_3Sn layer formed in the MR wire than that in the JR wire may result the reduction in B_{c2} value. Fig. 2 is non-Cu J_c versus magnetic field curves of present Sn-Ta based JR wire, and 19 and 37 rod MR wires at 4.2K. Non-Cu J_c's of ~120A/mm^2 and ~200A/mm^2 at 22T and 20T, respectively, are obtained at 4.2K in the 19 rod MR wire.

In Fig. 2 non-Cu areal fraction of Nb_3Sn layers in these wires are also indicated. The difference in non-Cu J_c among these wires may be originated to that in areal fraction of Nb_3Sn layers. The Nb_3Sn areal fraction of 37 rod wire is smaller than that of 19 rod wire due to the larger Nb barrier areal fraction. The insertion of central Nb core in the Sn-Ta rod may increase the areal fraction of Nb_3Sn layers in MR wires improving the non-Cu J_c of the wire.

The fabrication of multifilamentary-type wires may be much easier by the MR process than by the JR process. Present results indicate that the MR wire using Sn-Ta rods has enough potential to be used in the field range of 20-22T at 4.2K.

1) Tachikawa, K., et.al. : to be published in IEEE Trans. Appl. Supercond., Vol.19 (June, 2009).

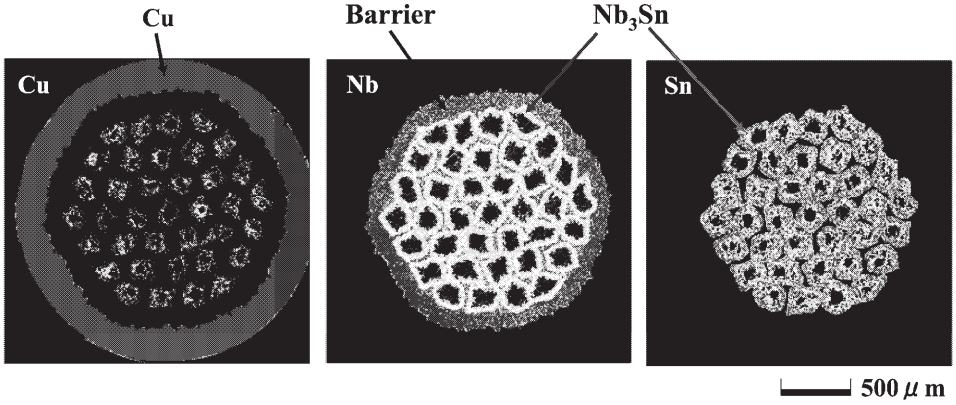

Fig. 1 EPMA mappings on the cross-section of 37 rod MR wire reacted at 750°C for 100h.

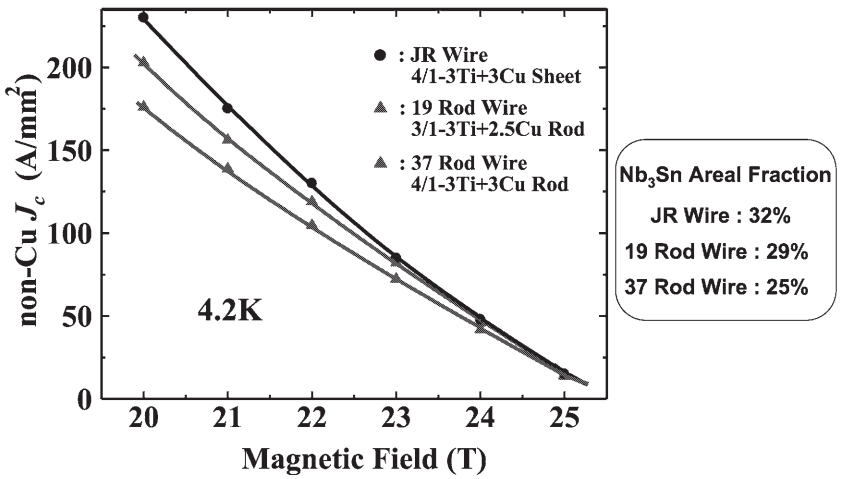

Fig. 2 Non-Cu J_c versus magnetic field curves of quoted JR and MR wires using Sn-Ta base alloy. Nb_3Sn areal fraction in the wires is also indicated.