§ 31. Research and Development of New Intermetallic Compound Superconductors

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Present authors recently fabricated $(Nb,Ta)_3Sn$ conductors using a composite of Ta-Sn reacted powder core and Nb(Nb-Ta) sheath[1]. In the present study, a new Jelly Roll (JR) process using Sn-Ta sheet richer in Sn has been investigated for the fabrication of $(Nb,Ta)_3Sn$ wires.

In the previous study the Ta-Sn reacted powder was prepared by the crushing after the melt diffusion, when the Ta concentration exceeds 40at%. Meanwhile, a Sn-Ta alloy with ductility can be prepared by the melting of Ta+Sn mixed powder, when the Ta concentration is below 30at%, as shown in Fig.1. The macrostructure of the resulting Sn-Ta alloy consists of the Ta powder dispersion in the Sn matrix. The Sn-Ta alloy with Ta/Sn ratio of 3/7 and 1/3 with or without 5wt%Cu addition were melted at 800℃ for 10h in vacuum. The melted Sn-Ta button was pressed into a plate and flat rolled into a sheet 0.20mm in thickness. Then the Sn-Ta or Sn-Ta-Cu sheet was laminated with Nb sheet 0.24mm in thickness, and wound around a Nb rod 2mm in diameter. The resuting Jelly Roll (JR) composite was encased in a Nb-4at%Ta tube with outer and inner diameter of 10mm and 7.5mm, respectively, as illustrated in Fig.1. The composite was fabricated into a 2.7mm square rod by grooved rolling, and then drawn into a wire 1.35mm in diameter using a cassette roller dies. The 3/7 and 1/3 JR wires were heat treated at 900℃ and 925℃, while the JR wires with Cu addition were heat treated at 775℃ and 800℃ in vacuum for 80h.

The midpoint of the transition temperature of the JR wires is 18.1~18.2K, which is higher than that of bronze-processed $(Nb,Ti)_3Sn$ wires by ~0.5K. Fig.2 illustrates the critical current (I_c) versus magnetic field curves of the JR wires. The non-Cu critical current density (J_c) of the wires is also indicated. The JR 3/7 wire reacted at 925℃ shows a larger J_c at 24T, however a smaller J_c in fields below 23T, than that of the wire reacted at 900℃. The 1.35mmϕ JR 3/7 wire reacted at 900℃ shows a non-Cu J_c of about $1.2\times10^4 A/cm^2$ at 23T and 4.2K. The Nb foil wound in the JR Sn-Ta core is expected to facilitate an effective consumption of Sn and Ta in the core to form $(Nb,Ta)_3Sn$ layers resulting a large non-Cu J_c of the wire. The JR 1/3+5Cu wire reacted at 775℃ shows a larger non-Cu J_c than that reacted at 800℃. This may be related to a finer grain size of $(Nb,Ta)_3Sn$ formed at a lower temperature. This is also the same case in JR 3/7 wires reacted at 900℃ and 925℃. A non-Cu J_c of over 1×10^4 A/cm^2 is obtained at 22T and 4.2K in the JR1/3+5Cu wire reacted at 775℃. The 5wt%Cu addition effectively decreases the optimum reaction temperature of the JR-processed wire.

In conclusion, new JR-processed $(Nb,Ta)_3Sn$ wires have been successfully fabricated using Sn-Ta and Sn-Ta-Cu sheets richer in Sn. No intermediate annealing is required in the wire fabrication. The present JR $(Nb,Ta)_3Sn$ wires show attractive high-field performance at 22-23T and 4.2K.

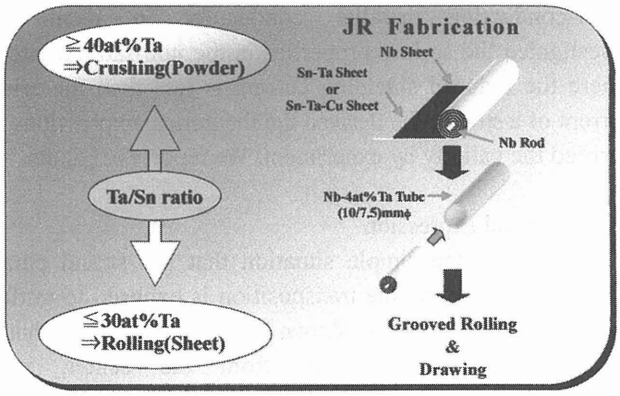

Fig.1 Mechanical properties of Ta-Sn system, and the JR process for the fabrication of $(Nb,Ta)_3Sn$ wires using Sn-Ta and Nb sheets.

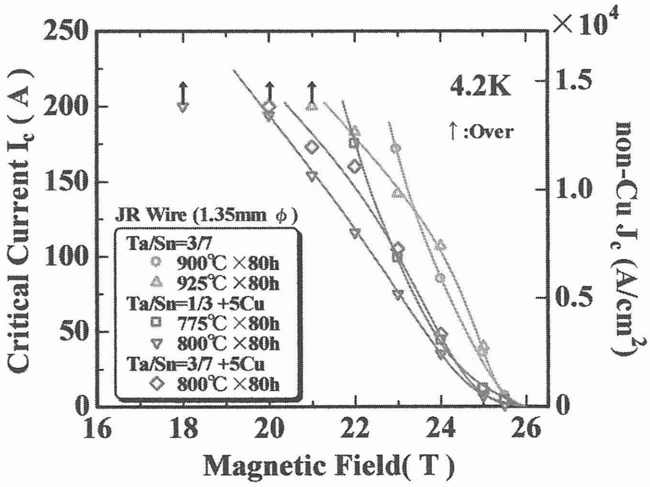

Fig.2 I_c and non-Cu J_c versus magnetic field curves of JR processed $(Nb,Ta)_3Sn$ wires with or without 5wt%Cu addition.

Reference

1) Tachikawa,K., Kato,R., Aodai,M. and Takeuchi,T., J.Japan Inst. Metals 66, (2002) 223 (in Japanese).