§19. Development of V-Ti and V-Ti-Ta Superconducting Alloy Conductors

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Superconductors in the practical fusion reactors will be exposed to heavy neutron irradiation during a long term. The use of Nb and Ag-based superconductors in the practical fusion reactor may force us to keep the superconducting materials in custody for a long term of more than several hundreds years in order to reduce their radioactivity below a safety level after the old fusion reactor shutdown. For avoiding the radioactivity problem we had better avoid the use of Nb and Ag. For the practical fusion reactor we should not use Nb_3Sn, Nb_3Al, Nb-Ti, Bi-2223, and Bi-2212 superconductors, which are the present commercialized supercon -ductors or the next generation practical ones.

We had better begin to develope the superconductors without Nb and Ag for the practical fusion reactor. We selected ductile V-Ti alloys as the substitution of the Nb-Ti alloys, which are the most popular commercialized superconductors at present due to their good ductility. The detailed practical superconducting properties of ductile V-Ti alloys have not yet reported. One of the present authors found that their B_{c2} is relatively low at 4.2 K, but becomes relatively high at 1.8 K comparably as those of Nb-Ti alloys in particular with the addition of Ta.

In this study arc-melted V-Ti alloy ingots were cold-drawn into long V-Ti wires, and then the V-Ti alloy wires were flat-rolled into the thin V-Ti tapes in order to reduce the flux jumps during I_c measurements.

The effects of α-Ti depositions, caused with the heat treatment at 300-500°C, were studied for various V-Ti alloys through T_c measurements, I_c measurements, and X-ray diffraction patterns. I_c increased with the α-Ti depositions for the investigated V-Ti alloys, as shown in Fig. 2.

By using V-(40-45)at%Ti alloys we fabricated 25-core multifilamentary wires of the Cu-10wt%Ni matrices. Improvement of stability was obtained for the multifilamentary V-Ti alloy wire without any flux jump during I_c measurements.

In Fig. 1, B_{c2}(4.2 K) vs. Ti content curves for the V-Ti alloys heat treated at various conditions are shown. In Fig. 2, J_c vs. B curves for the V-Ti alloys heat treated at 400°C and 450°C with various cold-drawing conditions are shown.

The maximum J_c(4.2 K, 6.5 T) of 200 A/mm^2 is obtained, which is not enough J_c for the practical applications. It is necessary to study much more to optimize the heat treatment conditions and the cold-drawing conditions. The heat treatment at the final stage causes degradations of not only B_{c2} but also T_c. However the cold-drawing at the final stage recovers the degradated B_{c2} and T_c values to the original values.

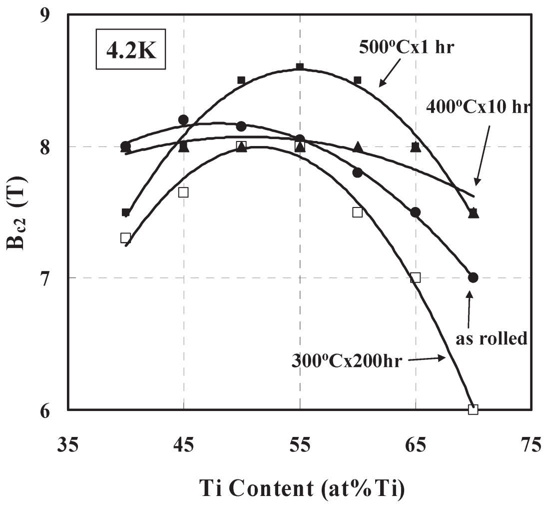

Fig. 1. B_{c2} vs. Ti content curves for V-Ti alloy tapes, as rolled, heat treated at 500°C for 1 hr, 400°C for 10 hr, and 300°C for 200 hr.

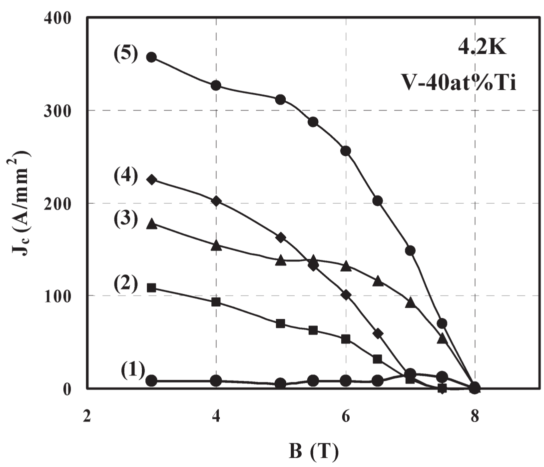

Fig. 2. J_c vs. B curves for V-40at%Ti multifilamentary wire. The curves (1), (2), (3), (4), and (5) shows the I_c of wires with the cold-reduction conditions and heat treatment conditions; (1) A.R.R. of 1200, (2) A.R.R. of 1200 + 400°C for 3 hr, (3) A.R.R. of 100 + 450°C for 3 hr + A.R.R. of 12, (4) A.R.R. of 1200 + 450°C for 9 hr, and (5) A.R.R. of 100 + 450°C for 3 hr + A.R.R. of 4 + 450°C for 3 hr + A.R.R. of 2 + 450°C for 3 hr + A.R.R. of 1.5, respectively, where A. R. R. is the area redaction ratio during the cold-drawing between the heat treatments.