§12. Analysis of J_c Properties in High Magnetic Fields for Low Activation Superconducting Wires

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It is necessary to consider the neutron irradiation effect on superconducting magnets of an advanced fusion reactor beyond the ITER project. V-based compound and alloy may be applied for a future fusion magnet because they have shorter decay time of induced radioactivity compared with Nb-based superconductor. We approach V_3Ga compounds as V-based low activation and high magnetic field superconducting materials for fusion application.

V_3Ga compounds have high upper critical magnetic fields (H_{c2}) above 20 T and better mechanical property than Nb-based compound. And then, the commercial processing of Nb_3Sn such as “Bronzed process” was developed by diffusion process of the V_3Ga wire. Although V_3Ga compound was older material compared with Nb-based material, we think that V_3Ga will have high potential performances for the fusion application. However, critical current density (J_c) properties of V_3Ga compound are lower than that of Nb-based superconductors and are insufficiency for the fusion magnet. No substitution effects of V_3Ga compound such as Ti substitution into the Nb_3Sn phase will be mainly caused by the lower J_c property. In order to improve superconducting property of V_3Ga compound, we have developed the new processing using high Ga content Cu-Ga compound and metal V matrix. In this study, we measured the superconducting properties under the high magnetic field using various High-Field Superconducting Magnet systems in Tsukuba Magnet Laboratory of National Institute for Materials Science (TML-NIMS).

V_3Ga compound mono-cored and multifilamentary wires were prepared by the high Ga content Cu-Ga compound (Ga:30at%~64at%) powder (filament) and metal V tube (matrix) through the Powder-In-Tube (PIT) process. These Cu-Ga compound powders were packed into V tubes, and then these precursors were cold-drawn to wire having 1.0mm diameter. The multifilamentary wires were also made by the restacking of mono-cored wire into V tube and restacked precursors were cold-drawn to wire having 1.0mm diameter. These wires were sintered in a vacuum. The thicker V_3Ga phase compared with conventional process was formed along the interface between V matrix and Cu-Ga powder filament.

Fig.1 shows that the magnetic field dependence of critical temperature (T_c) property in the Cu-30at%Ga/V mono-cored wire. From the results of T_c measurments, optimum heat treatment condition of mono-cored wires was 700℃for 50h and maximum T_c value was obtained to be about 15 K which was same property compared with conventional process. It was known that H_{c2} value was estimated by the formula shown in Fig.1 in the case of A15 phase. H_{c2} value was obtained to be 22.8 K and this value was 1.5 T higher than that of conventional process without substitution. Fig.2 shows that J_c-B performances of various high Ga content V_3Ga wires. In generally, H_{c2} value was shown by the extrapolation of Kramer plot ($Jc^{1/2}B^{1/4}$). H_{c2} property was depended on the Ga content into the precursor wires. And optimum Ga content was 50 at%Ga. These results suggested that the new processing using high Ga content Cu-Ga compound powder was one of the effective methods to improve superconducting property of V_3Ga compound wires. We thought that V_3Ga compound had clear possibility of candidate materials for Nb-system superconductor though the progress of further process optimization.

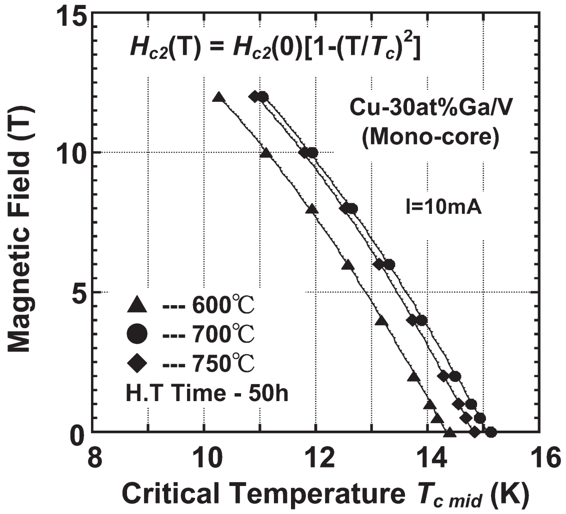

Fig. 1 The relationship between critical temperature and applied magnetic field on the Cu-30at%Ga/V mono-cored wire.

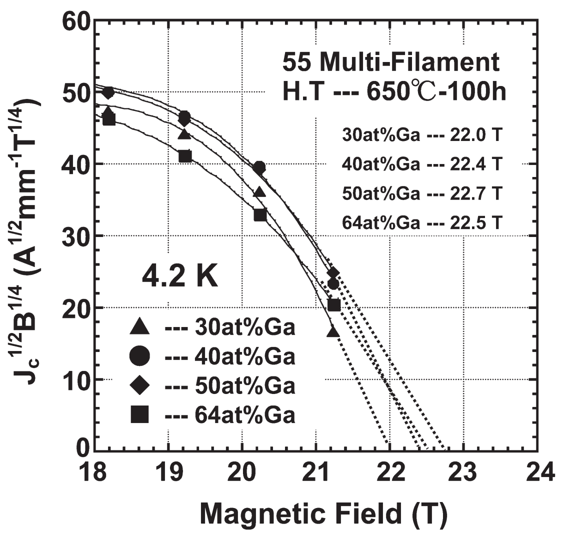

Fig.2 H_{c2} properties of the V_3Ga multifilamentary wires using various high Ga content compound estimated by Kramer formula.