§13. Development of V_3Ga Superconducting Wires by Using V-Ga and Ti-Ga Compound as High Ga Source Material

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V_3Ga compound superconducting material is attractive in the several V-based compounds as high magnetic field and low activation superconducting wire materials. V_3Ga compound has high upper critical magnetic fields (H_{c2}) above 20 T as well as Nb_3Sn and it is better mechanical property than Nb_3Sn compound. Furthermore, V_3Ga compound was historically origin material to succeed development of "Bronzed process" on commercial Nb_3Sn wire.

The wire process of V_3Ga compound was mainly investigated "Bronzed process" between Cu-Ga solid solution within 20 at%Ga composition and V filament. One of authors, Hishinuma et al., investigated that new route V_3Ga wire process synthesized by Powder In-Tube (PIT) process using high Ga content Cu-Ga compound powder above 20at%Ga composition. We also investigated that another PIT process using V-Ga binary system compound as the high Ga content compound.

In the previous study, we observed the microstructure of V_3Ga mono-cored wires via PIT process using Cu addition V_2Ga_5 and $TiGa_3$ compounds as high Ga source material. In this study, critical current density (J_c) property of V3Ga mono-cored wire using these compounds was measured. The comparisons between V_2Ga_5 and $TiGa_3$ on the superconducting properties are investigated.

Fig.1 shows that the effect of Cu addition on the J_c properties of $TiGa_3$/V and V_2Ga_5/V mono-cored wires. In Fig. 1, we plot the variation in V_3Ga layer J_c at 15 T with HT temperature for the $TiGa_3$/V and V_2Ga_5/V strand with and without Cu. The optimum heat treatment temperatures were shifted to lower temperatures by the Cu addition. We assume this is caused by the lowering of the melting points of the $TiGa_3$(Cu) and V_2Ga_5(Cu) compounds. The trend in increasing layer J_c values with decreasing HT temperature suggest that higher layer J_cs can be obtained below our minimum HT temperature of 700°C; For the $TiGa_3$/V+Cu, the J_c for the 700°C HT was already ~50% higher than the maximum value for the binary wire (HT at 750°C) and for the V_2Ga_5/V+Cu wires our data suggests that a 650°C HT will produce a higher layer J_c than the highest binary value (HT at 800°C). We believe that the lowering melting point by the Cu addition might result in the formation of the V_3Ga phase at lower heat treatment temperature, and that it was also effective in restricting the coarsening of the V_3Ga grains.

The J_c-B performances of the $TiGa_3$/V wire with Cu addition sintered at various heat treatment conditions are shown in fig. 2. The J_c-B performance of $TiGa_3$/V wires heat treated below 850°C were consistently higher than the Cu-40at%Ga/V wire. In the previous study, we confirmed that the J_c value was increased with increasing Ga composition in Cu-Ga compound filaments [1]. It suggested that the Ga composition in the Ti-Ga/V precursor wire was also an important factor in improving the J_c property in a manner similar to that in the Cu-Ga/V wire. Layer J_c degradation with increasing magnetic field above 14 T in the $TiGa_3$/V wire was clearly smaller than that for the Cu-40at%Ga/V wire. The coarsening of the V_3Ga grains was restricted using the high melting point $TiGa_3$ compound, suggesting that V_3Ga grains created via the $TiGa_3$/V precursor could be assumed to be mainly formed by solid state diffusion reaction without a liquid phase.

[1] Y. Hishinuma, et.al, Superconductor Science and Technology., Vol. 20, No. 6, (2007), pp. 569-573.

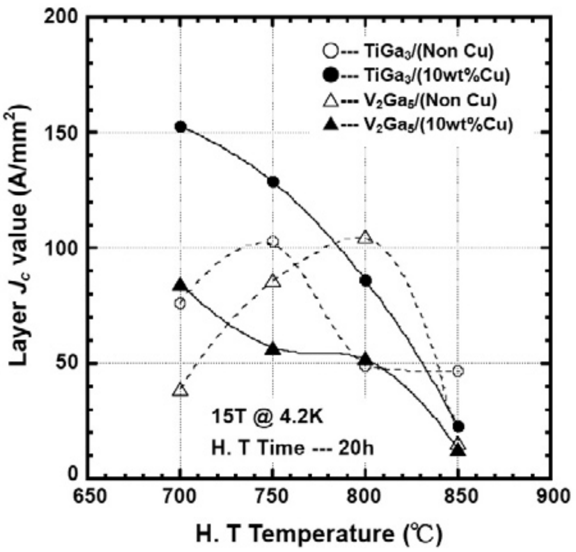

Fig. 1 The effect of Cu addition on J_c property at 15 Tesla in $TiGa_3$/V and V_2Ga_5/V mono-cored wires. Heat treatment time is fixed to 20 hours.

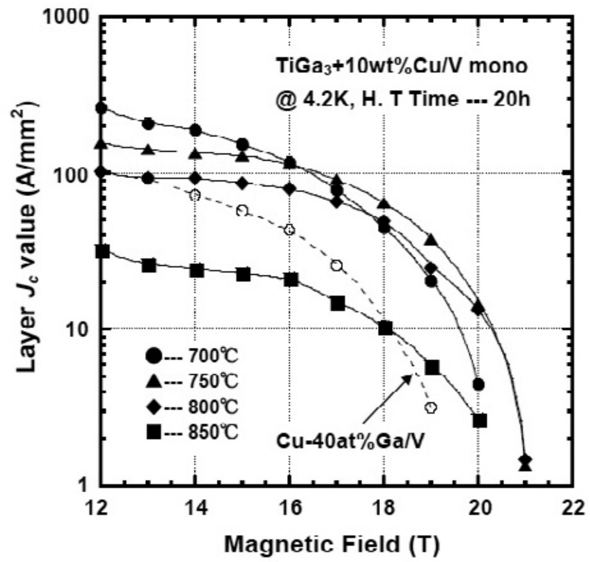

Fig. 2 Typical J_c-B performances of the $TiGa_3$ /V mono-cored wire with Cu addition sintered various temperatures. Heat treatment time is fixed to 20 hours.