§25. 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.

In the previous study, 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.

A lot of the high Ga content phases were existed in the V-Ga binary system, and they were V_6Ga_5, V_6Ga_7, V_2Ga_5 and V_8Ga_{41}, respectively. In the view points of the wire drawing process, V_2Ga_5 phase was desirable material in these high Ga content phases due to the high melting point above 1000℃. V_2Ga_5 compound was made by arc-melting method, and arc-melting button was carried out solution heat treatment at 800℃. From the EDX and EPMA analyses, base matrix and small amounts of the precipitate were confirmed to the V_2Ga_5 and V_8Ga_{41} compounds in the arc-melting button. The arc-melting button after the solution heat treatment was crushed easily by hand-milling. V_2Ga_5 compound was packed into metal V tube and the composite was carried our wire deformation, and then the diffusion pairs between V_2Ga_5 compound and metal V were prepared. And the other hand, Cu addition diffusion pair which was mixture of 10wt% Cu powder and V_2Ga_5compound was also prepared in order to study about Cu addition effect.

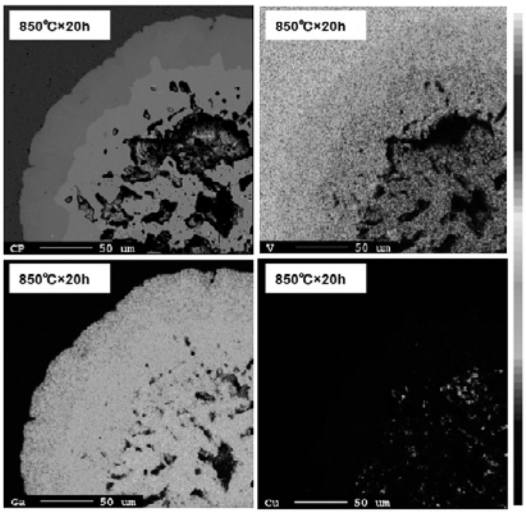

Fig.1 The element distribution into the diffusion layer on the V_2Ga_5+10wt%Cu addition /V precursor.

The comparison of the element distribution in diffusion layer on the V_2Ga_5+10wt%Cu addition /V precursor by EPMA analysis are shown in Fig.1. The thick diffusion layer was formed around the interface between V_2Ga_5 powder core and metal V matrix, and the volume fraction of V_3Ga layer was increased remarkably by the 10wt% Cu addition. Additional Cu did not diffuse into the V_3Ga phase, and it was confirmed clearly that additional Cu promoted to form V_3Ga phase as well as conventional “Bronzed process” of Nb_3Sn and V_3Ga wire.

The Ti-Ga compounds, which are $TiGa_2$ and $TiGa_3$, are the other high Ga content compound. These compounds are made by arc-melting as well as V_2Ga_5 compound. Because $TiGa_3$ and $TiGa_2$ compounds are high melting point materials above 1000℃. Fig. 2 shows back scattering electron (BSE) image of the arc-melted $TiGa_3$ button (as cast). As cast button, dendritic $TiGa_2$ compound was mainly formed into liquid metal Ga. The solid solution heat treatment as 800℃×10h was carried out the as cast button. After the heat treatment, $TiGa_2$ compound was reacted to liquid metal Ga, and $TiGa_2$ compound was transformed to the $TiGa_3$ compound. This compound was easy to crush to fine powder. $TiGa_3$ fine powder was packed into V tube, and $TiGa_3$/V composite precursor was drawn to mono-cored wire having 1.04mm diameter.

In the future, the superconducting property of the $TiGa_3$/V mono-cored wire will be measured. The comparisons between V_2Ga_5 and $TiGa_3$ on the superconducting properties and microstructure will also be investigated.

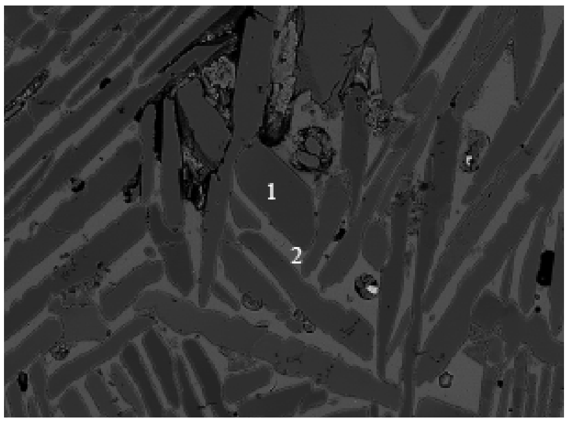

Fig.2 Typical back scattering electron (BSE) image of the arc-melted TiGa3 button. 1: $TiGa_2$, 2: non-reacted Ga (liquid)