§27. Development of V₃Ga Superconducting Wires by Using V-Ga Compound as High Ga Source Material

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V₃Ga compound superconducting material is attractive in the several V-based compounds as high magnetic field and low activation superconducting wire materials. V₃Ga compound has high upper critical magnetic fields ($H_{C2}$) above 20 T as well as Nb₃Sn and then is better mechanical property than Nb₃Sn compound. Furthermore, V₃Ga compound was historically origin material to succeed development of “Bronzed process” on commercial Nb₃Sn wire. In the previous study, the wire process of V₃Ga 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 V₃Ga wire process synthesized by Powder In-Tube (PIT) process using high Ga content Cu-Ga compound powder above 20at%Ga. 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 V₃Ga₅, V₆Ga₇, V₃Ga₂ and V₃Ga₇ respectively. In the view points of the wire drawing process, V₃Ga₂ phase was desirable material in these high Ga content phases due to the high melting point above 1000°C. V₃Ga₂ compound was made by arc-melting method, and arc-melting button was carried out solution heat treatment at 800°C. Typical back scattering electron microscopic image on the V₃Ga₂ compound after the solution heat treatment is shown in Fig.1. In the BSE image shown in Fig.1, two kinds of the V-Ga phases were formed. One is dark gray colored base matrix (1), another one is light gray colored dispersion precipitate into matrix (2). From the EDX and EPMA analyses, base matrix and precipitate were confirmed to the V₃Ga₂ and V₃Ga₇ compounds. The arc-melting button after the solution heat treatment was crushed easily by hand-milling. V₃Ga₂ compound was packed into metal V tube and the composite was carried our wire deformation, and then the diffusion pairs between V₃Ga₂ compound and metal V were prepared. And the other hand, Cu addition diffusion pair which was mixture of 10wt% Cu powder and V₃Ga₂ compound was also prepared in order to study about Cu addition effect. The comparisons between heat treatment temperatures on the element distribution in diffusion layer by EPMA analysis are shown in Fig.2. At heat treatment of 700°C, V₃Ga phase did not form in diffusion layer, however V₃Ga₅ phase was mainly formed. Main phase into diffusion layer was changed V₃Ga from V₃Ga₅ with elevating of heat treatment. Furthermore, the volume fraction of V₃Ga phase was also increased with elevating of heat treatment. These suggested that optimum heat treatment temperature of V₃Ga₅/V precursor was higher than that of Cu-Ga/V precursor. Fig.3 shows that the element distribution into the diffusion layer on the V₃Ga₂+10wt%Cu addition /V precursor. From the comparison of Fig.2, the volume fraction of V₃Ga layer was increased remarkably by the 10wt% Cu addition. Additional Cu did not diffuse into the V₃Ga phase, and it was confirmed clearly that additional Cu promoted to form V₃Ga phase as well as conventional “Bronzed process” of Nb₃Sn and V₃Ga wire.