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$V_3Ga$ compound superconducting material is attractive in 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 $V_3Ga$ 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 $J_c$ s 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.


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.