

## §22. Development of Low Activation Compound Superconducting Wires for Fusion Reactor

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V-based compound superconductors are suitable for applying as a high field conductor for advanced fusion reactors, because they show lower activation compared with those of Nb-based A15 wires. We investigated to develop the  $V_3Ga$  compound which was one of the V-based superconducting materials. The rapidly heating and quenching (RHQ) processing has been applied to various A15 compounds such as  $Nb_3Sn$ ,  $Nb_3Ga$ ,  $Nb_3Ge$  and  $Nb_3(Al,Ge)$  wires, bcc phase supersaturated solid solution filament like the  $Nb_3Al$  wire can not have been formed in each case. In this study, the RHQ process was applied at the  $V_3Ga$  compound which existed by stabilizing the V-25at%Ga solid solution in the high-temperature region above  $1300^\circ C$ . We focused and observed that the stacking fault was formed in the  $V_3Ga$  phase transformed from supersaturated solid solution as well as  $Nb_3Al$  compound.

$V_3Ga$  compound was produced to grinding by hands using Arc-melted  $V_3Ga$  compound button. Prepared  $V_3Ga$  compound powder was packed into Nb tube having 20 mm outer diameter and 10 mm inner diameter, and then this composite was cold rolled with a grooved and the wire drawn a diameter of about 2.00 mm through Powder-In-Tube method. This mono-cored wire was cut into short piece, and they were stacked into Nb tube. The number of stacked mono-cored wire was 55 pieces. The stacked composite was cold-rolled with a grooved roller and drawing machine to wire of about 0.74 mm diameter. This composite has good workability without breaking of wire during wire deformation, and average diameter of  $V_3Ga$  filament is about  $20\mu m$ . This multifilamentary wire was set into RHQ apparatus, and it was applied to the RHQ treatment in a dynamic vacuum chamber with moving at 0.4 m/sec of velocity. Then some of as-RHQ wires were additionally post-annealed at  $800^\circ C$  for 12 hours in vacuum.

Fig.1 shows that typical  $J_c$  dependence of magnetic field on  $V_3Ga/Nb$  multifilamentary wires.  $J_c$  was defined as the value which divided critical current ( $I_c$ ) by cross sectional area of  $V_3Ga$  filaments.  $J_c$  property of  $V_3Ga$  wire which post-annealed at  $800^\circ C$  for 12 hours was remarkably improved compared with as-RHQ wires under the magnetic field above 10 T. And then,  $H_{c2}$  value was also improved by post-annealing. Figs.2 and 3 show that the typical TEM image of the cross-section on samples before and after post-annealing. We found that the stacking fault was formed in the  $V_3Ga$  bcc phase supersaturated solid solution by RHQ as well as  $Nb_3Al$  compound shown in Fig.2. The grain size of  $V_3Ga$  phase which was transformed from bcc supersaturated solid solution by post-annealing was very small. We thought that the drastic

$J_c$  and  $H_{c2}$  improvement by post-annealing was caused by the small grain size of  $V_3Ga$  phase. We concluded that the applying of RHQ and post-annealing process was effective to form minute  $V_3Ga$  grains.

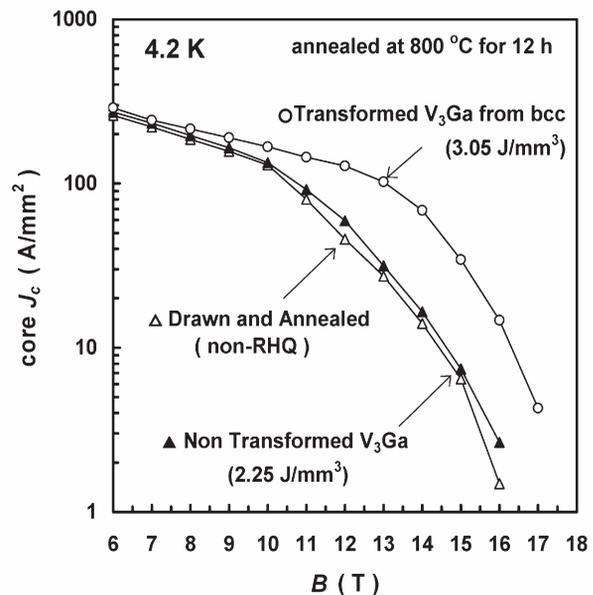


Fig.1  $J_c$  dependence of magnetic field on  $V_3Ga$  PIT multifilamentary wire using rapid-heating/quenching treatment

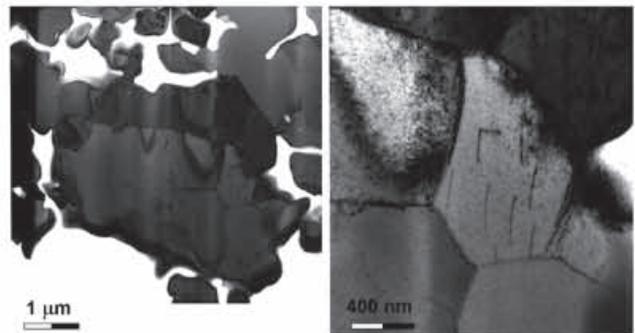


Fig. 2 Typical TEM image on the cross-section of the  $V_3Ga/Nb$  multifilamentary PIT wire after RHQ treatment.

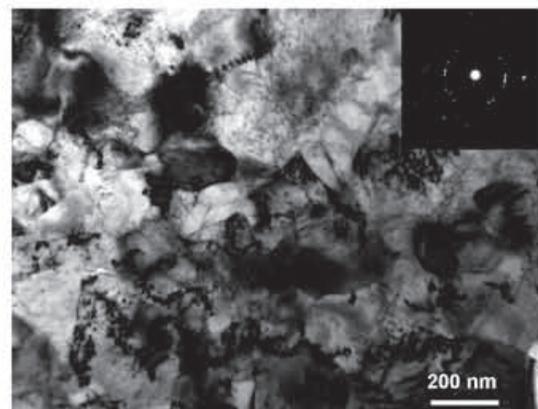


Fig. 3 Typical TEM image on the cross-section of the  $V_3Ga/Nb$  multifilamentary PIT wire after ordering treatment.