§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℃. 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 20μm. 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℃ 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. Jc property of V_3Ga wire which post-annealed at 800℃ 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.

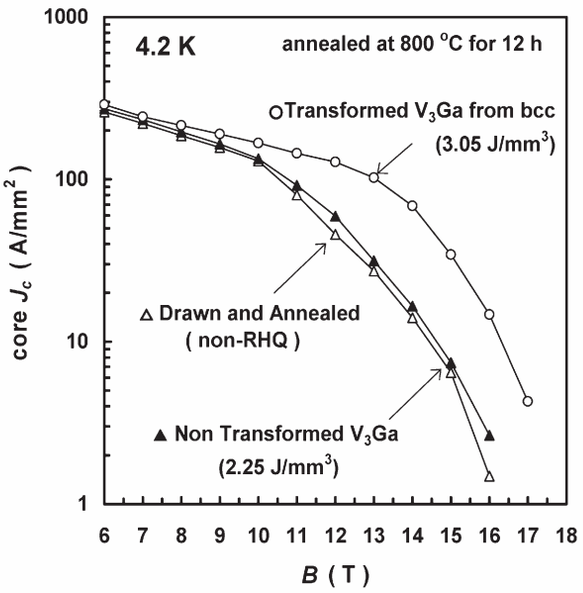

Fig.1 J_c dependence of magnetic field on V_3Ga PIT multifilamentary wire using rapid-heating/quenching treatment

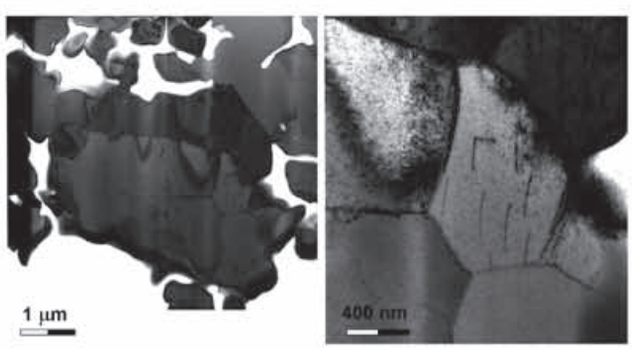

Fig. 2 Typical TEM image on the cross-section of the V_3Ga/Nb multifilamentary PIT wire after RHQ treatment.

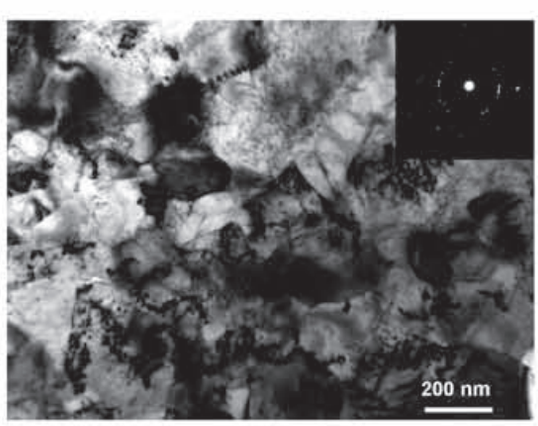

Fig. 3 Typical TEM image on the cross-section of the V_3Ga/Nb multifilamentary PIT wire after ordering treatment.