§14. Effect of Mg Addition on the Superconducting Properties in the V_3Ga Multifilamentary PIT Wires Using High Ga Content Compounds

Hishinuma, Y., Nishimura, A.,
Kikuchi, A., Iijima, Y., Takeuchi, T. (NIMS),
Taniguchi, H., Tomonaga, M. (Osaka Alloy Work, Co.,Ltd)

V_3Ga compound superconducting wire will be desirable as a candidate material to realize "low activation and high magnetic field superconducting magnet" for an advanced fusion reactor. Recently, we succeeded in developing new V_3Ga mono-cored and multifilametary wires, fabricated via the Powder In-Tube (PIT) process using the high Ga content compounds including above 50at%Ga composition with the aim of the J_c enhancement by the increase of V_3Ga volume fraction.

Although many investigations of the effect of substitution and impurities on the J_c of V_3Ga wire via diffusion process have been carried out for further J_c enhancement, no significant J_c improvement like the addition of Ti to Nb_3Sn wire was observed. Consequently, we also carried out Mg addition to the V_3Ga phase though a new PIT process, and the effect of Mg addition on the superconducting properties and microstructure of the V_3Ga phase were investigated.

Mg addition was applied using Cu-50at%Ga compound made using high purity Mg powder as the source material. The Mg-added compositions were 0.1, 1.0 and 5.0 at%Mg. The prepared Cu-Ga compounds were packed tightly into a high purity vanadium sheath tube and the precursor mono-cored wires were fabricated through the Powder-In-Tube (PIT) process. Wire drawing was carried out using grooved roller and cassette roller dies. Furthermore, multifilamentary wire was fabricated by cutting the mono-cored precursor wire into 19 short pieces and stacking them into a V tube.

The typical layer J_c-B property of Mg addition V_3Ga multifilamentary wires is shown to Fig.1. J_c values were defined as the I_c divided by the cross-sectional area of diffusion layer only, and will consequently be referred to as the "Layer J_c". The optimum heating temperature was higher than that of the non-Mg addition sample. The J_c-B properties of Mg addition samples were higher than that of the non-Mg sample. J_c was enhanced with increasing amount of Mg addition and the optimum amount of Mg addition of 1.0 at% was confirmed. As well as J_c, the H_{c2} was also improved by the Mg addition. Fig.2 shows that R-B property of the Mg addition samples. H_{c2} was shifted to higher magnetic field with increasing amounts of Mg addition, and 1.0 at%Mg addition was found to give to the maximum critical magnetic field. For the Mg addition to the V_3Ga phase, the H_{c2} value which was estimated by the J_c-B and R-B properties shown to Figs.1 and 2 was about 22.8 T, which is 2.5 T higher than that of the non-Mg addition sample. Mg addition into V_3Ga phase as low as 1.0 at% improved the superconductivity remarkably was confirmed. Typical Auger Electron spectra from the non-Mg and 1.0at%Mg addition samples are shown to Fig.3. The spectrum of non-Mg sample did not have a peak at 1188 eV. However, the peak of Auger spectrum around 1188 eV was confirmed clearly in the Mg addition sample. We infer that Mg addition to the V_3Ga phase was effective in improving J_c and H_{c2} properties and their enhancement was be caused by substitution of the Mg element into the V_3Ga phase.

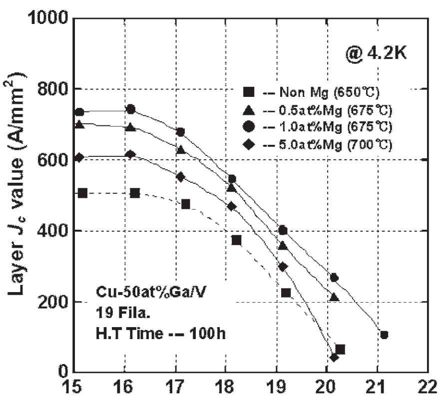

Fig. 1 Typical layer J_c-B properties of the Mg addition V_3Ga multifilamentary wires.

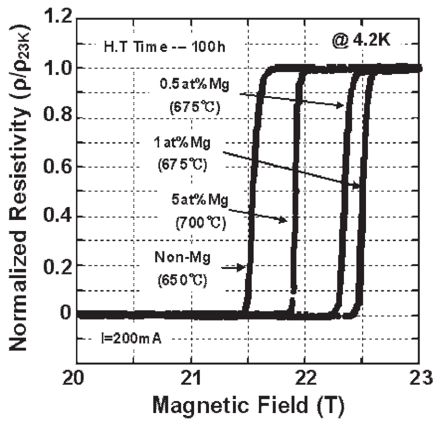

Fig. 2 The comparisons of the resistivity-magnetic field properties of the Mg addition V_3Ga wires.

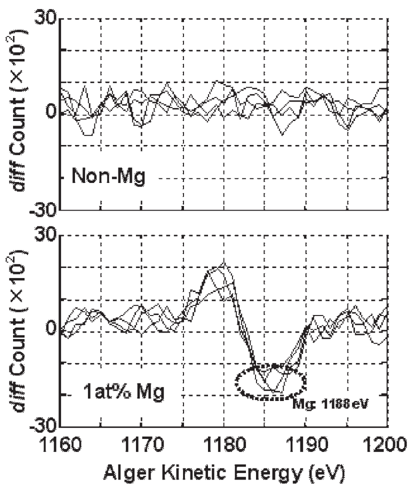

Fig. 3 Typical Auger Electron spectrum of the non-Mg and 1.0 at% Mg addition samples.