§10. Microstructure of V_3Ga Superconducting Wires Provided Ga from Ti-Ga Compound

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V_3Ga compound has low activation property and higher magnetic property among superconductors.[1] It is focused on the candidate of superconducting wire, because it has low sensitivity for strain rather than Nb_3Sn.[2] The drastic critical current density (J_c) improvement by increasing of Sn content in the Cu -Sn matrix on Nb_3Sn was reported. Hishinuma et. al. thought that the high Ga content in the Cu-Ga compound material was an effective method in order to improve J_c of the V_3Ga compound wire, just like for the high Sn content processed Nb_3Sn wires. And it was confirmed that the thicker V_3Ga layer formed along the interface of Cu-Ga powder core and V matrix compared with previous diffusion processed samples in the case of the multifilamentary wires. Upper critical field (H_{c2}) of the samples using high Ga content Cu-Ga compounds was increased with increasing of Ga content into Cu-Ga compounds. [3]

But there was no report about the microstructure of high Ga content Cu-Ga/V composite superconducting wire to form V_3Ga. In this work, we have investigated microstructures of V_3Ga phase formed by annealing on Cu-Ga/V wire fabricated by PIT method.

Its microstructure and crystallographic orientation relationships have been investigated mainly using SEM and TEM .

Fig. 1(a) shows SEM image of the cross-section of the of Cu-40at%Ga/V wire annealed at 873K for 10 hrs. There is a core of Cu-Ga surrounding darker contrast. Its darker contrast became thicker by longer annealing time of 200 hrs. Fig. 2 shows enlarged pictures of Fig. 1. In Fig. 2(a), we can see regions #1 and #2 between core and V pipe as different contrasts. In Fig. 2(b), it becomes clearer. Darker region #3 appeared instead of the region #1. Chemistry was also detected by SEM-EDS technique as shown in Fig. 3, and we have recognized 3 phases estimated the ratio of V/Ga, except to core and V pipes as follows; V_2Ga_5, V_6Ga_5 and V_3Ga. At the early stage of annealing, V_2Ga_5, appeared, and V_6Ga_5 was formed after that , and then, V_3Ga was formed after long time annealing. According to this result, we have proposed the following reaction process:

$$5Ga + 2V \rightarrow V_2Ga_5 \quad [1]$$
$$4V + V_2Ga_5 \rightarrow V_6Ga_5 \quad [2]$$
$$V_6Ga_5 \rightarrow 2V_3Ga + 3Ga \quad [3]$$
$$3Ga + 9V \rightarrow 3V_3Ga \quad [4]$$

(V_2Ga_5: region 1, V_6Ga_5:region 2, V_3Ga: region 3)

Our next target is more detailed investigation for this sample to obtain microstructure and crystallographic orientation relationships, and to lead the rule of increasing the volume fraction of V_3Ga phase in the future work.

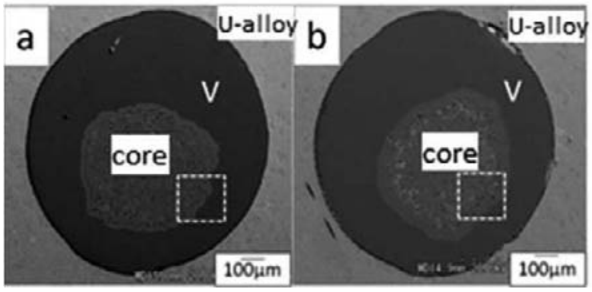

Fig.1 SEM image of cross section of Cu-40at%Ga/Vwire annealed at 873K for (a)10h and (b)200h.

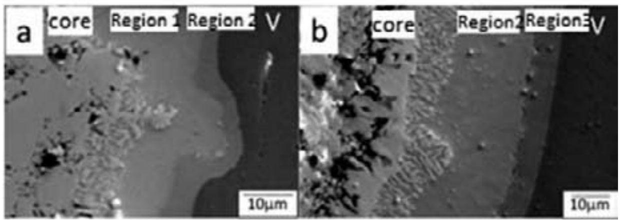

Fig.2 Enlarged SEM images of marked regions by doted squares in Fig.1. (a) 10h and (b) 200h.

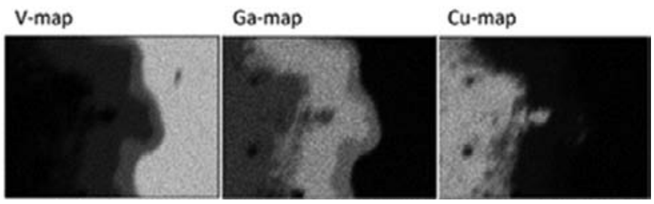

Fig. 3 V, Ga and Cu SEM-EDS maps obtained for the marked region in Fig. 1(a).

[1] T.Noda et.al, Fusion Engineering and Design, Vol.81, 8-14, 2006, p1033-1037.
[2] R.Flukiger et.al, Adv. Cryo. Eng, vol30, 1984, P851.
[3] Y.Hishinuma et al, J.Japan Inst. Metals, Vol.71 (2007) pp.959 – 965