A R C H I V E S O F M E T A L L U R G Y A N D M A T E R I A L S
Volume 58 2013 Issue 2
DOI: 10.2478/v10172-012-0191-4

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# MICROSTRUCTURE OF $V_3$Ga SUPERCONDUCTING WIRE USING HIGH Ga CONTENT Ti-Ga/V PRECURSOR COMPOSITE MATERIAL

# MIKROSTRUKTURA NADPRZEWODZĄCEGO DRUTU $V_3$Ga WYTWORZONEGO PRZY UŻYCIU ZWIĄZKU $TiGa_3$ O WYSOKIEJ ZAWARTOŚCI Ga

Our co-workers, Hishinuma et. al. have fabricated the V3Ga compound wire by a new process using a high Ga content Ti-Ga compound in order to improve the superconducting property of the wire. In this study, we investigated microstructures of this wire to clarify the existence of $V_3$Ga phase. The different contrasts of the matrix, two V-Ga phases and Ti-Ga core were observed by SEM observation. Two V-Ga phases were also confirmed. The ratio of V to Ga for two V-Ga phases was respectively 3:1 and 6:5 according to the EDS result. And these two phases were confirmed as $V_3$Ga and $V_6Ga_5$.
*Keywords*: Superconductor, Ti-Ga/V precursor composite material, V-Ga phase, TEM, microstructure

Hishinuma i współpracownicy wytworzyli drut związku międzymetalicznego $V_3$Ga przy użyciu nowej metody wykorzystującej związek międzymetaliczny Ti-Ga o wysokiej zawartości Ga celem poprawy właściwości nadprzewodzących drutu. Zbadaliśmy mikrostrukturę drutu, aby zweryfikować obecność fazy $V_3$Ga. W trakcie badań SEM zaobserwowano zróżnicowany kontrast w osnowie oraz istnienie dwóch faz V-Ga i rdzenia T-Ga. Analiza EDS potwierdziła istnienie dwóch faz z układu V-Ga, w których stosunek V do Ga wynosi odpowiednio 3:1 i 6:5. Potwierdzono, że te dwie fazy to $V_3$Ga i $V_6Ga_5$.

## 1. Introduction

A superconducting wire has been used in superconducting magnet system. It is also one of the important components in an advanced magnetic confinement fusion reactor [1]. In previous studies, Hishinuma et. al. tried to develop the new route for the fabrication of $V_3$Ga compound wire with high Ga content Cu-Ga compound using the PIT processed precursors in order to improve the cold workability and volume fraction of $V_3$Ga phase, and investigated its microstructure and superconducting properties. It was confirmed that both the critical current density (Jc) and upper critical field ($H_{C2}$) were enhanced for the Cu-Ga compound having Ga content over 40at. % [2-5]. In this work, $TiGa_3$ compound having Ga content over 70at. % was selected as a Ga source in order to increase volume fraction of $V_3$Ga phase. The microstructures of the superconducting wire with high Ga content $TiGa_3$ compound was investigated to clarify the existence of $V_3$Ga phase.

## 2. Experimental Procedure

Ti-Ga compound powders were filled up a V pipe and drawn into 1mm single filament wire. The single filament wire was cut into a proper length. The single filament wire was heat treated in Ar atmosphere to form the superconducting layer. The microstructure was investigated by SEM and TEM observation. Ti-Ga wire was polished mechanically to prepare the SEM sample. TEM sample was made from SEM sample using FIB method (FB-2100, HITACHI). SEM and TEM observations were performed using S-3500H with EDS and EM-002B (TOPCON) with EDS, respectively.

## 3. Results and discussion

SEM image for the cross-section of Ti-Ga wire was shown in Fig. 1. Fig. 2(a) shows SEM image of the region marked by a square in Fig. 1 and EDS map was obtained from the same area. Fig. 2(b), (c) and (d) were Ti-, Ga- and V-maps, respectively. According to these results, Ti and Ga were detected from Ti-Ga core, V was detected from V matrix. As illustrated in Fig. 2(c) and (d), two V-Ga phases existed between Ti-Ga core and V matrix. Fig. 3 shows TEM bright field images obtained for the sample prepared by FIB method from V-Ga phase of Ti-Ga wire. In Fig. 3(a), the broken line is an interface between $V_6Ga_5$ phase and $V_3$Ga phase. The shape of the interface between $V_6Ga_5$ phase and $V_3$Ga phase

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is complicated. The broken line in Fig. 3(b) is an interface between $V_3Ga$ phase and V matrix and EDS analysis was performed for all phases. The ratio of V to Ga for V-Ga phase in Fig. 3(a) was 6:5 and 3:1, and 3:1 and 10:0 in Fig. 3(b). So these phases are $V_3Ga$ and $V_6Ga_5$.

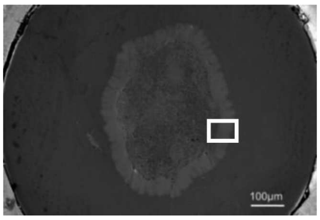


Fig. 1. SEM image for the cross-section of Ti-Ga wire

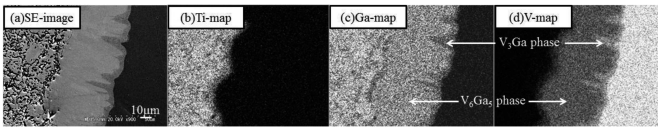


Fig. 2. Cross-section of Ti-Ga wire: (a)SE image, (b)Ti-, (c)Ga- and (d)V-maps

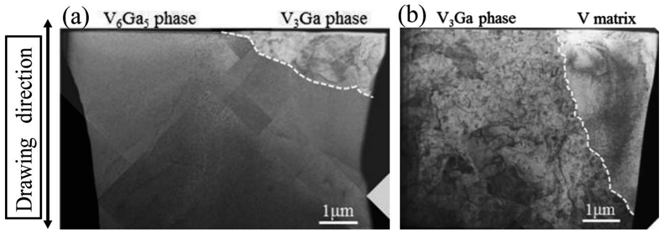


Fig. 3. TEM bright field images of (a)$V_6Ga_5$ phase/$V_3Ga$ phase, (b)$V_3Ga$ phase/V matrix

*Received: 20 January 2013.*

## 4. Conclusions

The four contrasts of the matrix, two V-Ga phases and Ti-Ga core were observed by SEM observation in the cross section of single filament wire. From SEM-EDS analysis, the ratio of V and Ga for two V-Ga phase was 3:1 and 6:5.Thin film sample with V-Ga phase for TEM was fabricated by FIB technique and observed by TEM in detail. Two V-Ga phases were $V_3Ga$ and $V_6Ga_5$ according to their TEM-EDS results and selected area diffraction patterns.

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