WBP8-1

Use of Cu-Mg alloy matrix in internal diffusion process Nb_3Sn wires

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We are exploring new effects by elemental addition into Cu matrix in internal diffusion process Nb_3Sn wires [1]. In particular, Zn is an attractive additive in terms of growth kinetics for Nb_3Sn layer formation: it enhances the Sn activity in brass (Cu-Zn) matrix. Recently, we newly tried Mg addition. Mg addition is expected to be effective to refine the grain morphology and accelerate the layer growth. Single stacked type Nb_3Sn wires were fabricated using Cu-1wt% Mg as matrix in this work (Fig. 1 (a)). We investigated the microstructure and superconducting characteristics through microstructural and micro-chemical analysis.

Heat treatment at 650 ℃ was not sufficient for Sn diffusion across the inner Cu matrix. After the heat treatment at 700 ℃ for 200 h, Sn diffused sufficiently across the outer Cu-1Mg matrix to form Nb_3Sn layer. A small amount of Cu-Sn-Mg phase was recognized in the matrix. EDS mapping results indicate that Nb_3Sn layer in the Cu-1Mg matrix sample seems thicker than that in the pure Cu matrix sample. Fig. 1 (b) shows the grain morphology of the Nb_3Sn filament. The grain size shows finer feature near the boundary of the Cu-alloy matrix. As pointed out in a previous work for V_3Ga [2], it is believed that Mg diffused just into the near-matrix area of the Nb_3Sn layer and segregated at the grain boundary. The Cu-1Mg matrix wire was also heat treated at 750 ℃ for 50 h and 800 ℃ for 20 h. The higher temperature appreciably brought grain growth: the average Nb_3Sn grain size increased from 0.256 μm to 0.340 μm with increasing the temperature from 700 to 800 ℃ as shown in Fig. 1 (c). The grain morphology remained equiaxial microstructure even at 800 ℃. The Nb_3Sn grain growth seems much faster than the layer growth, when we compare the microstructures at 700 ℃ and 800 ℃. Fig. 1 (d) compares the matrix J_c of the samples. Matrix J_c of the Cu-1Mg sample has a tendency of decreasing with the increase of heat treatment temperature.

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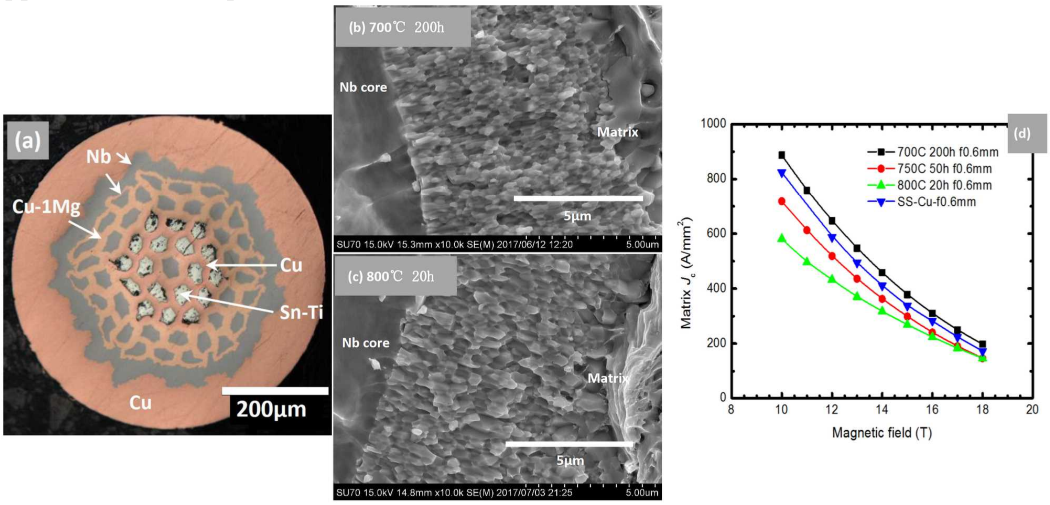

Figure 1. Cross section FESEM images of the (a) SS type wires with Cu-1Mg matrix and (b) samples heat treated at 700 ℃ 200h, (c) 800 ℃ 20h, and (d) matrix J_C characteristics as a function of magnetic field.

Keywords: Nb3Sn, Cu alloy matrix, Mg addition, internal tin process

WBP8-2

Preparation of Nb_3Al superconducting tapes by a powder-in-tube method combined with hot-pressed sintering

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The precursors of Nb-Al tape were fabricated by a powder-in-tube (PIT) technique. Supersaturated solid solutions of Nb-Al powder were obtained by high-energy ball milling, followed by a powder-in-tube process to prepare series of Nb_3Al precursor tapes. Compared with sintering under normal pressure, the hot-pressing sintering greatly increased the critical current density of the tapes. The results showed that the Nb_3Al tapes prepared via the powder-in-tube method and hot-pressed sintering could significantly improve the J_c performance, and the value of Jc (8K, 0T) was higher than 6×10^5A/cm^2. The Nb_3Al tapes after pressing under the pressure of 20 MPa and sintering at 950°C for 3h had the best magnetic flux pinning performance, and the sample reached the maximum flux pinning force ($F_{p,\ max}$) of 3.28109N/m^3 in the magnetic field of 2.2 T.

Keywords: Nb3Al superconducting tape,　Mechanical alloying, Powder-in-tube, Hot-pressed sintering

WBP8-3

Effect of Bending Strain on Critical Current of Reacted MgB_2 Mono- and Multi-filament Wires

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This study investigates the superconducting properties of reacted mono- and multi-filament MgB_2 wires, manufactured by Kiswire Advanced Technology Co., Ltd., with respect to bending diameter through a three-point bending test method using a lab-made bending test probe. The critical current of the mono-filament wire was not degraded as the bending diameter decreased to 30 mm, whereas that of the multi-filament wire initially decreased at a bending diameter of < 210 mm. Moreover, the multi-filament wire at a bending diameter of < 210 mm exhibited the existence of a resistive zone within the sample, which was caused by the cracks propagated thoroughly in the transverse direction of the wire. Overall, the mono-filament wires could be utilized in most superconducting applications in terms of the bending diameter, whereas the bending properties of the multi-filament wires should be improved for use in superconducting applications that require a bore size of < 210 mm.

Keywords: MgB2, Superconductor, Bending test, React and wind

WBP8-4

Fabrication Process and Pressure Dependence of Critical Current Density in $Ba_{1-x}K_xFe_2As_2$ Superconducting HIP Wires

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High critical current density, J_c, is realized in superconducting wires and tapes using 122-type iron-based superconductors (IBS). The value of J_c in these wires and tapes strongly depends on their fabrication and sintering processes such as drawing, cold/hot uniaxial pressing, and hot isostatic press (HIP). Reported HIP wires have been processed at high pressure of 1000-2000 atm for 4-20 h [1-2]. However, sintering pressure and time dependence of J_c in the HIP wire have not been systematically studied yet. So the sintering condition for the HIP wire still has rooms for improvements. On the other hand, we have recently reported that wire fabrication process has strong influence on J_c in the HIP wire [3]. Round wires drawn using dies with circular holes before groove-rolling ("drawn") have higher J_c than those fabricated using only a groove roller with square grooves ("rolled").
In this work, first, we systematically investigate how the sintering conditions such as pressure and time affect the J_c performance in HIP wires, by preparing wires at different pressures and for various times. Second, we investigate how different mechanical deformation processes affect J_c characteristics of HIP wires by comparing properties of "rolled", "drawn", and "swaged" (swaged by a rotary swager) wires. Preliminary results of magnetic field dependences of magnetic J_c in HIP wires fabricated using different processes and pressures are shown in the figure. J_c in three HIP wires, which were sintered at 90 atm, indicate that adding drawing or swaging processes are effective to enhance J_c. Furthermore, in the case of "drawn" wire, J_c is higher when it is sintered at higher pressure. These improvements may be closely related to the suppression of the degradation of the core during fabrication process [4] and weak links between grains including their texturing and microcracks. Details of the various fabrication process, more systematic pressure and time dependence of J_c, and evaluations of properties by *I-V* characteristics, magnetization, and x-ray analyses will be presented.

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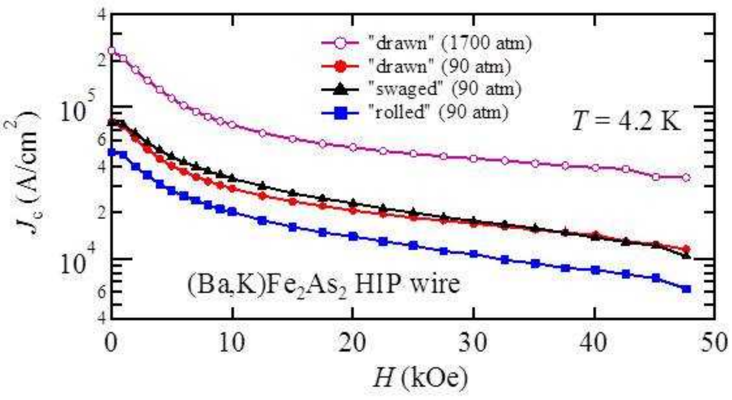

Fig. Magnetic field dependence of magnetic J_c in several HIP wires.

Keywords: Iron-based superconductor, Ba1-xKxFe2As2, Critical current density, HIP wire

WBP8-5

Enhancement of Critical Current Density in AgSn-sheathed (Sr,Na)Fe_2As_2 Superconducting Tapes

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'122 types' iron-based superconductors are extensively studied for both basic science and applications. In particular, (*AE*,K)Fe_2As_2 (*AE* = Ba,Sr) superconducting wires and tapes have been widely studied for its very large critical current densities (J_c) even at high fields [1]. Recently, a new material joined this kind of research, namely (Sr,Na)Fe_2As_2 [2]. The reported transport J_c at 20 K up to 25 kOe is comparable to that in (*AE*,K)Fe2As2 tapes in the same condition. Following this study, we have fabricated (Sr,Na)Fe_2As_2 tapes by using Ag sheath and achieved transport J_c as high as 19 kA/cm^2 at 4.2 K and 140 kOe [3]. However, in the tape with the highest J_c processed at 875 ^{o}C, strong reaction between the core and Ag sheath was observed. Recently, excellent J_c characteristics in AgSn-sheathed (Ba,K)Fe_2As_2 tapes processed at relatively low temperatures has been reported [4]. In the present work, we report the fabrication of (Sr,Na)Fe_2As_2/AgSn tapes and their J_c characteristics. In (Sr,Na)Fe_2As_2/AgSn tape sintered at 750 ^{o}C, J_c reached 47 kA/cm^2 at 50 kOe, which is higher than that of the Ag-sheathed tape sintered at 875^{o}C. This result indicates that we have succeeded in reducing the sintering temperature by more than 100 ^{o}C, keeping the high J_c value. We will also report compositional distributions and magneto-optical images of current distribution in tapes processed under different conditions.

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Keywords: Superconducting tapes, (Sr,Na)Fe2As2, Critical current density, Powder-in-tube (PIT)

WBP8-6

Fabrication and Critical Current Properties of Powder-in-tube $Ba_{1-x}Na_xFe_2As_2$ Wires and Tapes

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Iron-based superconductors, which possess high critical temperatures T_c (the maximum T_c is 55 K) and upper critical fields of over 100 T, are promising for high magnetic field applications. [1] Especially, 122-type superconductors such as (Ba,K)Fe_2As_2 and (Sr,K)Fe_2As_2 having small anisotropy seem to be suitable for powder-in-tube wires and tapes. Much effort has been devoted to fabricating those wires and tapes adequate for practical use. Meanwhile, we have shown that Na-doped 122 materials are comparable to or even better than (Ba,K)Fe_2As_2. Recently, we reported that (Sr,Na)Fe_2As_2 tapes have a high critical current density J_c exceeding 10^4 A/cm^2 at 20 K under 2.5 T, demonstrating that Na-doped materials are also promising.[2] Remarkably, micrograins of a Ag-As alloy are produced in the superconducting core without adding Ag to the starting powders. It is expected that such conductive alloys play an important role in the grain connectivity or the flux pinning and thus likely induce high J_c. It would be significant to investigate other Na-doped 122 materials such as (Ba,Na)Fe_2As_2.

In this study, we fabricated superconducting wires and tapes using another Na-doped material, (Ba,Na)Fe_2As_2 and measured their transport J_c. Figure 1(a) shows J_c at 4.2K and 20K as a function of magnetic field parallel to the tape surface. A high transport J_c of 4×10^4 A/cm^2 at 4.2 K under 4 T is obtained, exceeding a transport J_c of (Sr,Na)Fe_2As_2 tapes. Moreover, J_c values over 10^4 A/cm^2 persist over a wide range of magnetic fields. Figure 1(b) shows a SEM image of the cross section of a superconducting core. The small white spots were found to be Ag alloys. Besides this, substantial amounts of voids and Fe_2As impurities were also observed (black and dark grey regions, respectively), suggesting that there is much room for improvement in fabrication process. More details will be given in the presentation.

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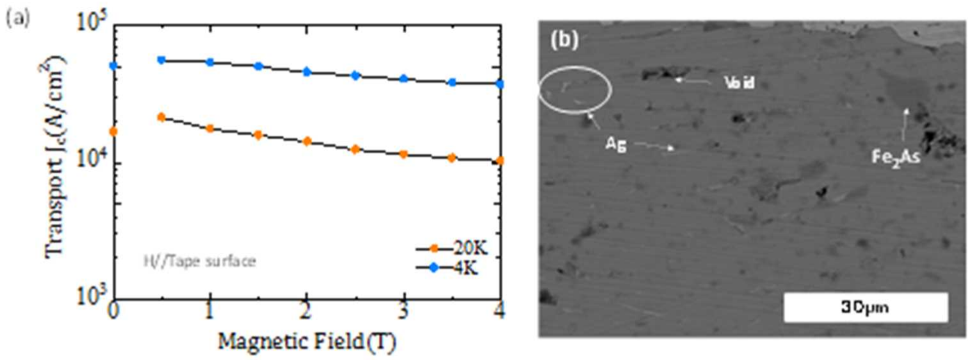

Fig1 (a) $J_c - \mu_0 H$ curves of (Ba,Na)Fe_2As_2 tape at T = 4.2 K and 20K with H parallel to the tape surface. (b) SEM image of the cross section of (Ba,Na)Fe_2As_2 tape

Keywords: Iron-based superconductors, Powder-in-tube wires and tapes, Critical current density