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Superconducting Critical Current Densities for $Sr_2VFeAsO_{3-\delta}$ Wires Fabricated by *ex-situ* Powder-in-tube Process

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Abstract

Superconducting wires were fabricated via an *ex-situ* powder-in-tube (PIT) process using a Fe/Ag bimetallic sheath as a sheath material and $Sr_2VFeAsO_{3-\delta}$ as a core material. The superconducting wires were prepared by a solid-state reaction in an evacuated quartz tube at 900°C for 1, 2, and 4 h after being rolled. The superconducting wires exhibited zero resistivity at temperatures ≤ 8-12 K. Critical current densities (J_c) of the superconducting wires were determined from their *V-I* curves. The J_c was extrapolated up to 45.3 Acm^{-2} at 0 K for the 1 h-sintered wire.

Keywords: Iron-based superconductor, Perovskite-related structure, Superconducting wire, $Sr_2VFeAsO_{3-\delta}$.

1. Introduction

Since the discovery of iron-based superconductor [1] in 2008, several iron-based superconductors were discovered, such as FeSe (11 phase) [2], $Ae_{1-x}K_xFe_2As_2$ (122 phases, *Ae*: Alkali earth elements) [3], LiFeAs (111 phase) [4], $ReFeAsO_{1-x}F_x$ (1111 phases, *Re*: rare earth elements) [1], and perovskite-related $Sr_2T_MFePnO_{3-\delta}$ (21113 phases, T_M: transition metal elements, *Pn* = P, As) [5-7]. These iron-based superconductors exhibit relatively high upper critical magnetic flux density at temperatures (*T*) below superconducting transition temperatures (T_c). Therefore, iron-based superconductors are promising for applications under high magnetic fields [8-10].

Several researchers have reported superconducting wires using 122 [11-16], 1111 [17-21] and 11 [22, 23] phases as core materials via powder-in-tube (PIT) process [10], although superconducting critical current densities (J_c) of the superconducting wires have been lower than those of superconducting single crystalline samples. Such a lowering of J_c is called as a weak-link. The weak-link is mainly due to two factors. A factor is a decreasing of J_c due to grain boundaries' geometry. [24, 25] The other factor is an inhomogeneous and a phase segregated chemical states that are often observed for complex superconducting materials. Indeed, a superconducting thin film, which shows axially oriented crystallographic phase with a homogeneous chemical state, exhibits large J_c as well as single crystalline superconducting samples. [26, 27]

In order to enhance J_c, various approaches have been reported to exclude the weak-link; e.g. additions of low melting point metals such as Ag [11], Sn [17, 18], hot isostatic pressing (HIP) [12, 14], and an uniaxial pressing after flat rolling [13]. The various approaches are tried to demonstrate both of axially oriented crystallographic phase and homogeneous chemical state in a polycrystalline bulk samples for superconducting wires.

For the 1111 phases, a reactive solid state binder (RSB) method was employed to compensate the loss of F during heat treatments in 2011. The superconducting wires fabricated by RSB method reached 4000 Acm^{-2} at 4.2 K under a magnetic flux density (μ_0H) = 0.03 T [19, 20]. In recent, J_c of superconducting tapes increased to 3.95×10^4 Acm^{-2} at 4.2 K under self-field [17], to 1.8×10^4 Acm^{-2} at 4.2 K under μ_0H = 0.6 T, and to 2.9×10^2 Acm^{-2} at 4.2 K under μ_0H = 10 T [18] by low-temperature synthesis with Sn adding. For the 122 phase, various chemical compositions such as $Ba_{1-x}K_xFe_2As_2$ [14], $Sr_{1-x}K_xFe_2As_2$ [15], and $Sr_{1-x}Na_xFe_2As_2$ [16] were employed for the fabrication of

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