Standardization of superconductivity (VAMAS TWA 16 / IEC TC 90)

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NIMS has been developing not only superconducting materials but also superconducting magnets and standardization since the era of NRIM. We have been aiming to develop superconducting materials as industrial materials. This article introduces an outline of standardization activities related to superconductivity in NIMS.

1.Introduction

NIMS has contributed not only to superconducting material developments but also superconducting magnet developments since the era of NRIM, e.g. bronze-route Nb_3Sn superconducting wire[1)], a 17.5 T superconducting magnet[2)], an 18.1 T superconducting magnet[3)], a discovery of the Bi-based superconductor[4)], a 21.1 T superconducting magnet[5)], world record of static magnetic field generated by a hybrid magnet[6)], a 920 MHz (21.6 T) NMR superconducting magnet[7)], a 930 MHz (21.9 T) NMR superconducting magnet[8)], a 1020 MHz (24.0 T) NMR superconducting magnet[9)], 30 T generation using high temperature superconducting coils[10)], etc. We also have been working on standardization of superconducting materials from an early stage. This article introduces an outline of standardization activities related to superconductivity in NIMS.

2. History of superconductivity standardization

The Technical Working Aria (TWA) on superconducting materials was organized as TWA 6, which covered superconducting and cryogenic structural materials, in 1986. It became independent as TWA 16 (Superconducting materials) in 1993[11)]. The first chairperson of the TWA was the late Dr. Kyoji Tachikawa (Director of Tsukuba Branch of the NRIM at that time). A research group of NRIM played a role of the secretariat. Later, the chairperson of TWA 16 was a researcher in NIMS (NRIM), i.e. Dr. Hitoshi Wada (ex-Director of High Magnetic Field Research Station), the late Dr. Kikuo Ito (ex-Chief Researcher of Superconducting Materials Center), and Dr. Hitoshi Kitaguchi (Deputy Director of Research Center for Functional Materials), for generations. I have been the chairperson of TWA 16 since 2014.

In the International Electrotechnical Commission (IEC), a 90th Technical Committee, TC 90: Superconductivity, was established in 1989. Japan became the secretariat because of the active superconducting research and development in Japan[12)].

VAMAS TWA 16 has been in a formal liaison relationship since the beginning of IEC TC 90. In addition, most of the 26 international standards published so far from TC 90 are based on results of round robin tests promoted by VAMAS TWA 16.

3. Recently published international standards

3.1 Retained critical current after double bending at room temperature of Ag-sheathed Bi-2223 superconducting wires

To develop devices using Bi-based high-temperature superconducting wires, the wires will be bent by passing through pulleys. This standard describes a test method to

Figure 1. Double bending at room temperature for Bi-based high temperature superconducting wire

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determine the retained critical current after double bending at room temperature. After the wire is double-bent along the mandrel as shown in Fig. 1, the critical current is measured in liquid nitrogen. The standard was based on the international round robin test, which was conducted at five institutions in Germany, Korea, and Japan including NIMS[13)] in FY2014, and was published on June 18, 2018[14)].

3.2 Room temperature tensile test on REBCO wires

This standard describes the test method to evaluate tensile mechanical properties of RE-Ba-Cu-O (REBCO; RE=rare earth) superconductive tapes at room temperature. Due to the brittleness of the REBCO material and the thin tape-shape of the composite tape, special care should be taken when measuring strain. The standard was based on the international round-robin test, which was conducted at seven institutions in Japan, Korea, Germany, and China in FY2013[15)], and was published on August 29, 2018[16)].

3.3 Critical current of REBCO composite superconductors

The critical current measurement is the most basic measurement to investigate the electrical properties of superconducting wires. Although among the superconducting wire that are commercially available, international standards of critical current measurement methods have been published for NbTi, Nb_3Sn, and Bi-based superconductors, not yet for REBCO. In response to requests from manufacturers, an international round robin test at 11 institutions in Japan, South Korea, the United States, Italy, and France in FY2014[17)]. Based on the result of this RRT, a new work item was proposed in 2017[18)]. The standard was published on June 11, 2020[19)].

4. Ongoing international standards

4.1 Tensile test method of high temperature superconducting wires at cryogenic temperatures

Equipment using high-temperature superconducting wires are usually operated in cryogenic temperatures below liquid nitrogen temperature. Since strain will be applied to the wires during operation, tensile tests at cryogenic temperatures are essential to evaluate the wire characteristics. To standardize this test method, an international round-robin test, which was lead by Dr. N. Bagrets of Karlsruhe Institute of Technology, Germany, was conducted at 8 institutions in 6 countries, e.g. Karlsruhe Institute of Technology (Germany), Tufts University (United States), University of Twente (Netherlands)[20)], etc. A new work item proposal (NP) is currently prepared.

4.2 Critical current measurement of high temperature superconducting wires under tensile stress

Assuming a high-temperature superconducting devices operated in liquid nitrogen, the critical current measurement under tensile stress is planned to be standardized. In other words, it is a combined measurement of 4.1 and 4.2 above. A guideline for the international round robin test, which is lead by Prof. H.-S. Shin of Andong National University, South Korea, is under consideration.

5. Summary

Since its inception, VAMAS TWA 16 (superconducting materials) has contributed to pre-standardization of superconducting materials by international round-robin tests and measurement technique developments. VAMAS TWA 16 also contributed to most of the international standards published by IEC TC 90. Although it is hard to say that we have made sufficient contributions because of budget decreases in recent years, we will continue to contribute as much as possible.

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