Summer, 2010 Date of Issue: July 15, 2010

超電導 Web21 Superconductivity

Superconductivity Web21

Published by International Superconductivity Technology Center
1-10-13 Shinonome Koto-ku, Tokyo 135-0062, Japan Tel:+81-3-3536-7283, Fax:+81-3-3536-7318

Contents:

Top of Superconductivity Web21

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13 Shinonome, Koto-ku, Tokyo 135-0062, Japan
Tel: +81-3-3536-7283 Fax: +81-3-3536-7318
Top of Superconductivity Web21: http://www.istec.or.jp/Web21/index-E.html

KEIRIN

This work was subsidized by the Japan Keirin Association using promotion funds from KEIRIN RACE
http://ringring-keirin.jp

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Report on the 18th International Superconductivity Industry Summit (ISIS-18)

Akihiko Tsutai, Director,
International Affairs Division, ISTEC

The 18th International Superconductivity Industry Summit (ISIS-18) was held from February 9 (Tue) to 11 (Thu), 2010 at Wellington, New Zealand. While ISISs have been held by rotation in Japan, USA, and Europe so far, the conference was held in New Zealand, which newly joined as a member country last year, for the first time. About 40 people participated in the conference from Japan, USA, Europe, New Zealand, and Korea. The conference consisted of the Pre-ISIS meeting (February 9) in which general public were allowed to participate and the ISIS meeting (February 10 and 11) in which only summit members participated.

Other than the lecture by Shiohara, Director General of SRL, on the long-term prospects for the practical use of YBCO wires from the viewpoint of CO_2 reduction, lectures were given by lecturers from USA, Europe, New Zealand, and Korea. New Zealand is promoting the development and business focused on various superconducting devices and systems, taking a strategy of aligning with overseas partners to take their advantages in areas outside their specialty. In the pre-ISIS meeting in which not only experts but general public also participated, various presentations were made, ranging from basic educational lectures to highly specialized ones on how to commercialize superconductivity in the future and how to create long-term business chances.

In the ISIS sessions, following an opening greeting by the mayor of Wellington, where the conference was held, lectures were given and views were exchanged regarding large-scale electric-power equipment, electronics magnet, and future problems. From Japan, Yu Shiohara, Director General of SRL/ISTEC, made a national report on a general overview on superconductivity technology development in Japan, focusing on the present status of the development of YBCO wire and future plans. In addition, Tsukushi Hara, General Manager of R & D Center of Tokyo Electric Power Company, Keiichi Tanabe, Deputy Director General of SRL/ISTEC, and Noboru Fujiwara, Director of Electric Power Equipment Division of SRL/ISTEC, reported Japan's present status and future plans on the demonstration project for high-temperature superconducting cables, development of superconducting electronics, and development of Y-based electric-power equipment, respectively. In USA, two superconductor wire manufacturers, American Superconductor and SuperPower, are playing a central role in the development of YBCO wire in cooperation with national laboratories and universities. In addition, equipment using superconducting wires is being actively developed under SPI and SPE Programs. In the field of electronics also, development and business of superconducting circuits and superconducting filters are being promoted aggressively. In Europe, efforts are made for the practical use of MgB_2, and the wires are already in the market and application to magnet is being promoted. In the field of HTS wire, application to motors, generators, and induction heaters are being developed or commercialized. In New Zealand, at present, Roebel cable, with the aim of application to electric power devices, is being developed and research and development for applying the supeconductors to transformers is being implemented. A company selling HTS magnets as superconductor related products (HTS110) is actively working. In Korea, the Development of the Advanced Power system by Applied Superconductivity technologies (DAPAS) Project, which started in 2001, has entered the final phase, and the GENI Project led by Korean Electric Power also has started. Thus they are moving forward to accelerate the practical use of high-temperature superconductors.

Since the new Obama administration started last year in USA, the smart-grid project aiming at a new

electric-power grid with robustness, reliability, economic efficiency, high efficiency, and environmental friendliness has been strongly promoted. This smart grid related movement is expanding all over the world. In this smart-grid technology, the superconducting technology is expected to play an important role and people see new business opportunities in it. Energy security together with the global-warming issue is a big problem to deal with all over the world. The energy-saving technology will bring about continuous economic growth and the superconducting technology is a promising option for this end. All the countries of the world are developing the superconductivity technology toward its expanding commercial application, acknowledging that the technology is very important. This ISIS-18 conference was an epoch-making event because it was held in New Zealand, which had newly joined as a member of the superconductivity club, and the author hopes that the circle of superconductivity, including its commercialization, will expand worldwide further.

The author had a strong impression that public organizations, including the New Zealand government, actively supported the ISIS-18 as the Minister of Trade attended the dinner of the conference and the Mayor of Wellington made an opening greeting before the ISIS-18 sessions. The local paper, The Dominion Post, carried two superconductivity-related articles, including the ISIS-18 during the conference period, which would represent New Zealand's deep interest in the conference.

The next conference will be held in October, 2010 in Italy.

Photo Yu Shiohara, Director General of SRL/ISTEC, giving a lecture at ISIS-18

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

New Project "Development of Advanced Nondestructive Biosensing Technology Using High-Temperature Superconducting SQUID" has started

Seiji Adachi, Associate Director,
Electronic Devices Division, SRL/ISTEC

Japan Science and Technology Agency (JST) started the "Strategic creation and promotion of innovation (S-innovation*)" project in 2009. The purpose of this project is to establish innovation by consistent long-term (maximum of 10 years) research and development for the basis of industrial creation. In this fiscal year, four to five research and development plans on each of the four themes (iPS cell, organic electronics, photonics polymer, and superconductivity) have been adopted through open symposium, public offering, hearing, and selection. “Development of advanced nondestructive biosensing technology using high-temperature superconducting SQUID,” which is one of the plans, has been started.

The outline of the project is as follows. A SQUID system with a high sensitivity and reliability comparable to low-temperature SQUID is developed by bringing out the maximum potential of high-temperature SQUID magnetic sensor making it possible to apply it in various industrial fields. For this purpose, elemental technologies such as high-temperature superconducting SQUID utilizing multilayer technology, high-sensitivity sensor system, and advanced magnetic imaging technology are established. By integrating these elemental technologies, an advanced nondestructive biosensing technology with unconventional high performance and new functions will be established. Consequently, biosensing technology for medical diagnosis and regenerative medical techniques will be developed in order to be applied to immunological tests, detection of cardiac-muscle cell grown in vitro, magnetocardiographic detection, and ultra-low magnetic field MRI. In addition, nondestructive inspection system is developed for batteries important in energy field, and analysis and evaluation of water that plays an important role in agriculture. Through the development and evaluation of the prototypes of these devices, the basic technology for superconducting sensing equipment will be established, thereby realizing demonstration tests aiming at practical use.

"S-innovation" is a project that brings practical use into view, and business companies and universities are the members of the development team, which consists of Kyushu University, Hitachi, Ltd., Hitachi High-Technologies Corporation, Toyohashi University of Technology, Okayama University, and ISTEC. Leaders of the research and the development teams are Prof. Keiji Enpuku (Kyushu University) and Dr. Akihiko Kandori (Hitachi), respectively. The role of SRL/ ISTEC in the project is to upgrade the oxide multilayer structure and processing technology of ramp-edge junction that have been accumulated in order to develop optimum SQUID chips for various applications. In the past, application research for high-temperature SQUID chips that are prepared by patterning processing of single-layer superconducting thin films such as bicrystal junction and step-edge junction were conducted. In this project, SQUID having a multilayer structure, which has not been used much, is adopted and an advanced system will be developed taking into consideration the practical application in diversified fields.

* http://www.jst.go.jp/s-innova/index.html

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Superconductivity-related project has started under Funding Program for World-Leading Innovative R&D in Science and Technology

Keiichi Tanabe, Deputy Director General,
SRL/ISTEC

Funding Program for World-Leading Innovative R&D on Science and Technology (FIRST) was budgeted in the first supplemental budget of the last fiscal year with the purpose of promoting research and development placing maximum priority on researchers by establishing a support system that allows researchers to devote themselves to their work and provides researchers with flexible use of research funds over multiple fiscal years in order to strengthen the research and development ability and international competitiveness of Japan. In last September, the Council for Science and Technology Policy selected 30 researchers who will represent Japan and also selected research projects that aim at the top of the world. In the selection, the theme “Search for new superconducting materials and related functional materials, and industrial application of superconducting wires” with Prof. Hideo Hosono of Tokyo Institute of Technology as the leader and Tanabe of ISTEC as a co-proposer was taken up. As a result of reduction of the total budget, the research plan and budget plan of each theme were appraised by an expert assembly of people as key members, and the research funds and support organizations for each theme were decided on March 9 by three top officials of the Cabinet Office and the expert assembly of people.

Prof. Hosono of Tokyo Institute of Technology, who has a prominent track record in the discovery and commercialization of many new materials, including transparent semiconductors, is famous for his discovery of iron-based superconductors in 2008, which belongs to a new group of high-temperature superconducting materials. “Search for new superconducting materials and related functional materials, and industrial application of superconducting wires” is a five-year (including 2009) project and the total budget is ¥3.24 billion, including indirect costs. Tokyo Institute of Technology plays the role of a supporting organization of this project. In this project, Prof. Hosono of Tokyo Institute of Technology serves as the leader, the ”Material Search Team” consisting of Professor Hosono’s team, Prof. Kageyama’s team from Kyoto University, Prof. Yamanaka’s team from Hiroshima University, and Muromachi’s team from National Institute for Materials Science search for functional materials around new high-temperature superconducting materials; “Wire Application Team” consisting of Advanced Materials & Physics Division and Electronics Devices Division of SRL/ ISTEC group and Kumakura’s group from NIMS promotes the application of iron-based materials and new superconducting materials discovered by the ”Material Search Team” to wires and electronic devices and development of wires using promising superconducting materials. Kumakura’s group from NIMS studies the application of the powder-in-tube process (PIT), which has been effective for Bi-based materials, and of MgB_2 to wire manufacturing. ISTEC carries out the evaluation of flux-pinning characteristics and grain-boundary characteristics of thin films of these materials and their application in devices. When a promising material for wires is discovered, it is scheduled that ISTERA established by ISTEC and wire manufacturing companies last year takes the role of developing thin-film-based wires in the latter half two years of the project.

Although the maximum T_c of iron-based superconducting materials is 55 K at present, which is lower than that of copper-oxide-based superconductors, it has advantageous properties including a critical field as high as 100 T, s-wave symmetry, and anisotropy Γ= 2–5 smaller than those of Y-based copper oxides, and the fact that the undoped material is not an insulator but is a metal. Since there are several thousands of materials that have a structure similar to iron-based superconducting materials, it is quite probable that a new high-temperature superconducting material advantageous for industrial application with a T_c higher

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

than the liquid nitrogen temperature (77 K), small anisotropy, and good grain-boundary characteristics, which does not include harmful elements, can be found. This project starts with the development of application technologies such as preparation of wires, thin films, and devices using the present iron-based superconducting materials to accumulate basic technologies specific to this material group so that full-scale development of wires and devices can be quickly implemented when a new promising superconducting material is discovered by the material search team and intellectual properties including basic patents for the material and for the basic technology are secured resulting in leadership in the world.

(Published in a Japanese version in the April 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Kick-off of New National Project

Teruo Izumi, Senior Researcher
Industrial Superconductivity Technology Research Association (ISTERA)

The development group consisting of Tohoku University, Waseda University, Nagoya University, Kyushu University and Industrial Superconductivity Technology Research Association (ISTERA) started new national project. They are mainly working for the process development of 1 km long Y-system superconducting tapes, which are expected for realization of the light weight motors with high performance. If the magnetic coils using long Y-system superconducting tapes are realized, they could substitute for the Nd-Fe-B permanent magnets. The ISTERA was established by ISTEC, Fujikura and SWCC Cable Systems at September 24th, 2009 for the purpose of R&D of the tapes and the industrial applications.

In the Nd-Fe-B permanent magnet which is widely used, Dy element is substituted for the part of Nd site. Both Dy and Nd, especially for Dy, belong to “rare metals”, and therefore, it is required to save the use of the metals. As one approach, it is recognized that the use of coil magnet made by Y-system superconducting tapes is effective to reduce the weight of rare earth elements to 1/10 for the equivalent generated power. In order to realize high efficient and high performance motor, long tapes in one piece is necessary for lower connecting loss and higher mechanical strength of the coils. Then, the target of the project was set as a process development for the longer tape than 1 km with high I_c value of 300 A/cm-width. For the theme, the PLD and TFA-MOD processings are selected.

Additionally, the innovative processings, which is possible to reduce the use of rare earth further, and the motor design suitable for the Y-system superconducting tapes are also developed in the project.

The success of the project leads to not only reduction of use of rare earth elements but realization of 1 km long tape with high performance. Furthermore, the direction for the future development of Y-system superconducting rotating machine is also indicated.

(Published in a Japanese version in the June 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010

超電導 Web21 Superconductivity

Superconductivity Web21

Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Yu Shiohara, Director General of SRL/ISTEC, received the Special Award of Superconductivity Science and Technology from the Society of Non-Traditional Technology

Memorial lecture of Shiohara

On April 13, 2010, Yu Shiohara, Director General of SRL/ISTEC, received the special award of Superconductivity Science and Technology from the Society of Non-Traditional Technology at Tower Hall Funabori. This award is granted to those who have shown eminent achievements in research on superconductivity science and technology. The 14th special award was granted to Yu Shiohara and Akira Yamamoto (Head Professor, Cryogenics Science Center, High Energy Accelerator Research Organization) who has contributed to the development of superconductivity in the field of accelerator science. Furthermore, Science and Technology Award was granted to six groups. After the memorial lecture of the special award, award ceremony of Super Conductivity Science and Technology Award was held.

The award was granted to Shiohara for his contribution to the development of yttrium-based superconducting wire and its application. He has led the research on yttrium-based superconducting wire and its application in Japan for many years. He is also active internationally serving as a member of the assessment committee of a national project of the US Department of Energy. Therefore, the award was granted because of such prominent contribution to the development of present superconductivity science and technology.

The theme of his memorial lecture was “Development of yttrium-based superconducting wire and its application.” At first, he introduced the trends in the global environmental issues led by politicians in USA and Japan. Temperature rise due to greenhouse gases including CO_2 at global environmental level was explained and reduction targets of major countries by 2020 were shown. Relating to the reduction measures for CO_2 in Japan, it was particularly pointed out that superconductivity technology can contribute to the development of wind-power generation and electric-power transmission cables. Then, relating to the achievements of the national project,

“Technological Development of Yttrium-based Superconducting Power Equipment,” the status of the development of superconducting magnetic energy storage (SMES) system, superconducting electric-power cable, superconducting transformers, and yttrium-based superconducting wires were introduced. He showed that the length and characteristics of wires have reached the level at which the development of devices can be started, thereby leading to further development project for full-scale devices. Finally, he emphasized that he would promote, in the future, the research on superconducting technology that contributes to solve environmental and energy problems as a solution to Japan’s most important political issues and closed his lecture by commenting that his achievements owe to the cooperation of member companies and universities of ISTEC.

Shiohara receiving the Special Award

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Commemorative photo of the awardees of the 14th Superconductivity Science and Technology Award

(Editorial Office)

(Published in a Japanese version in the May 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Korea-Japan Superconductivity Workshop was held (2010 Korea-Japan Superconductivity Workshop)

Noboru Fujiwara, Director
Electric Power Equipment Division, SRL/ISETEC

On April 15 (Thu), 2010, the 1st Korea-Japan Superconductivity Workshop was held in Changwon, Korea. Changwon is a city with a population of about 500,000 located west of the Pusan Airport (about 30 min by car) and is famous as the city where Korea Electrotechnology Research Institute (KERI) is situated.

In the workshop, researchers of Korea and Japan joined together to exchange high-level and frank information aiming at early commercialization of superconducting electric devices. Recently, in both countries, results of research relating to the application of high-temperature superconducting wires to electric devices such as motors have been actively reported and research plans are being intensively scheduled.

Conference room where the oral session was held

About 50 people participated in the workshop from Japan and Korea. There were 24 presentations in total including oral and poster sessions, and ardent discussions took place.

From Japan, fourteen people attended the workshop from ISTEC, Tokyo Electric Power Co., cable manufacturers, and universities. They reported on latest research results of “M-PACC Project” and “Yokohama Project” in which demonstration test of superconducting is scheduled at Asahi Substation of Tokyo Electric Power Co. Furthermore, ISTERA (Industrial Superconductivity Technology Research Association) reported on a new project for the development of YBCO wire with a length of 1 km and research on HTS motors.

Korea reported on projects for superconducting power cable, HTS fault current limiter, SMES (superconducting magnetic energy storage), smart-grid project, as well as the present status of the development of coated conductors. Specific subjects included a plan to connect actual substations (distance: 3 km) with superconducting cables, a project for demonstration test of superconducting cables as part of the test to introduce a smart grid in Jeju, the results of the development of a 1-MW motor and plan for the development of a 5-MW motor, and results of the research on wires by EDBC process (production capacity: 0.9 km/day with 100 A/4–mm width). Extraordinary enthusiasm of related Korean people for commercialization and early practical realization was strongly felt.

超電導 Web21 Superconductivity

Superconductivity Web21

Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

On April 16 (Fri), we visited KERI and CAST as part of an optional tour. We observed the research site of superconductivity, high-voltage test facilities, and research on normal induction motors.

Since CCA2010 is going to be held in Fukuoka from October 28 to 30, it was decided that the next workshop will be held on the preceding October 27 in Fukuoka.

At the entrance of the hotel where the workshop was held

Reference:

1. KERI：Korea Electrotechnology Research Institute http://www.keri.re.kr/english/
2. CAST：Center for Applied Superconductivity Technology http://www.cast.re.kr/english/e_index.html
3. CCA：International Workshop on Coated Conductors for Applications
http://www.cca2010.org/index.html

(Published in a Japanese version in the May 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Completion of experimental apparatus for 200-meter superconducting DC cable

Sataro Yamaguchi, Professor
Superconductivity/Sustainable Energy Center
Chubu University

1. Introduction

Chubu University built an experimental apparatus for a 20-meter class cable in a five-year project funded by the Ministry of Education, Culture, Sports, Science, and Technology, which started in 2005, and multiple ideas have been tested to confirm the basic performance. Fortunately, this apparatus is the world's first apparatus as a DC superconducting power-transmission system using high temperature superconducting tape conductor and the initial targets have almost been accomplished. On the basis of the research results, the construction of the test apparatus for the 200-meter class cable was started in 2008 using an aid from NanoOpto Energy Inc. and completed in December 2009. Cooling and current tests have been implemented in the period from January to March 2010. This paper is a preliminary report that outlines the history of the construction and characteristics of the apparatus.

2. Completion and characteristics of the experimental apparatus for 200-m class cables

The process of designing the apparatus was started in July 2008 and various devices were ordered. The laboratory building was completed in July 2009. The assembly of the experimental apparatus was started in August and the setup was completed in December. Figure 1 shows the layout in the completed laboratory building. Electricity is transmitted between Terminal A and Terminal B. One unit of Stirling refrigerator (1 kW at 77 K) made by Aisin Seiki Co. is used. The circulation pump was also made by Aisin Seiki Co.

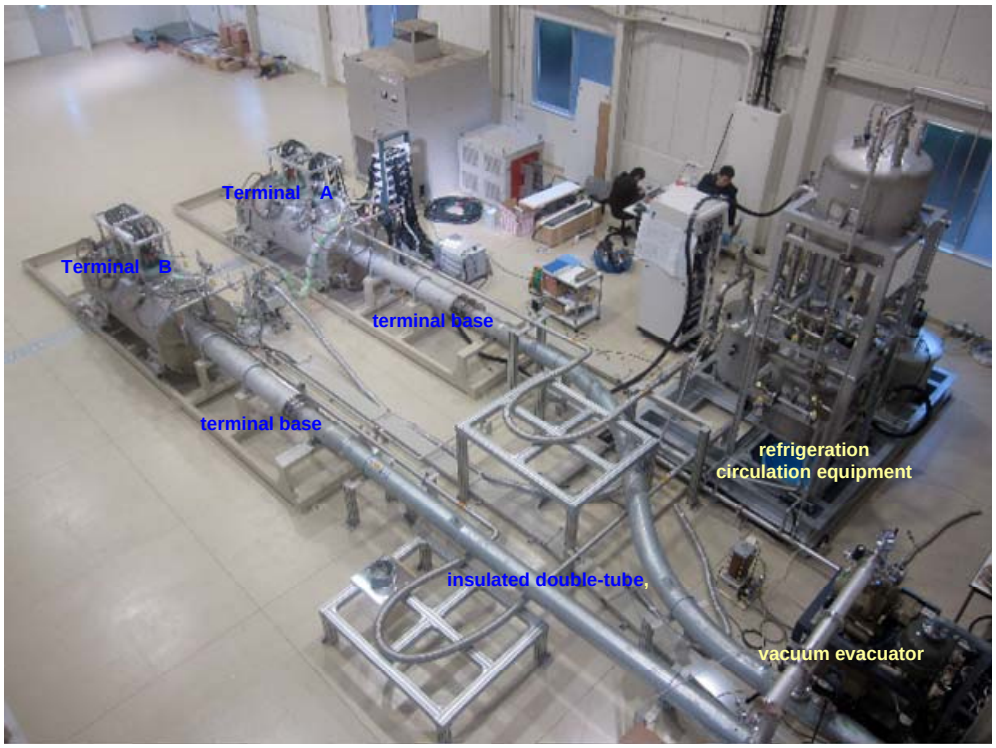

Fig. 1 Layout inside the laboratory

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Figure 2 shows the double-tube that contains the superconducting cables outside the laboratory building. Major features of the experimental apparatus are as follows:

1) The outer tube of the thermally insulated double-tube is a steel tube, which is straight.
2) Dynamic bellows are used to absorb heat contraction of the SC cable, and the terminal cryostat is made movable.
3) To reduce the heat penetration at the end, a Peltier current lead is used.
4) To make the electric current flowing through the HTS tape wires uniform, current lead parts are divided for each tape wire.

Since the superconducting cable is pulled in after the insulated double-tube is fabricated, the laying operation differs from the conventional method. The operation of pulling in the cable is shown in animated film. Because there is no AC loss and the heat penetration into the double-tube is low, the circulation of liquid nitrogen was targeted ~~at~~ as low as 10 L/min. For this reason, the circulation system was designed with low pressure loss.

Operation for pulling in the cable (animated film)

Fig. 2 Insulated double-tube (outside the laboratory building)

The evacuation test and the cooling down were completed in one week. Then the refrigeration circulation test was conducted for about a month so that stable circulation was obtained at about 10 L/min. After that, current test up to 1.2 kA was implemented, and the temperature was raised from March 8. Various types of tests are scheduled for 2010.

Reference:

1) H. Hamabe *et al*, IEEE Trans. Applied Supercond. 17(2) (2007) 1722-1725.及びY. Nasu *et al*, Proc. ICEC/ICMC, Seoul, Korea (2008) 489-494.
2) S. Yamaguchi *et al*, J. Physics, Conference Series 97 (2008) 012290.
3) Y. Ivanov *et al*, Trans. Cryogenic Eng., Conf. vol. 55, (2010).

(Published in a Japanese version in the May 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

What's New in the World of Superconductivity (March, April & May, 2010)

Akihiko Tsutai, Director
International Affairs Division, ISTEC

Award

Industrial Research Ltd. (March 9, 2010)

Two scientists at Industrial Research Ltd. (New Zealand), Dr. Bob Buckley and Dr. Jeff Tallon, have received the inaugural Prime Minister's Science Prize for their efforts in the development of high-temperature superconductivity technology as a new, high-value industry for New Zealand. The prize includes an award of NZD $500,000, of which $400,000 will be used by IRL for the continued development of high-temperature superconductivity. Dr. Buckley commented, "Winning this award shows that science is now being recognized for the contribution it makes to New Zealand's future economic well-being. While we are proud of the scientific achievements we have made, the real payoff for New Zealand will be witnessed in the next decade as HTS technology starts to make an impact in the global marketplace."
Source:
"IRL scientists scoop PM's Science Prize"
Industrial Research Ltd. press release (March 9, 2010)
http://www.irl.cri.nz/newsroom/media-release/irl-scientists-scoop-pms-science-prize

Nexans (April 1, 2010)

Nexans has won the first ever Energy Master Award 2010 for its superconducting current limiter; the product won first prize in the "Use of Innovative Technology" category for its application in the internal power supply of a power plant in Germany. Part of the reason why the award was given to Nexans is the potential application of the fault current limiter as a component in smart grids and the field of CO_2 separation. The final decision regarding the award was made by the public through online voting. Dr. Joachim Bock, Managing Director of Nexans Superconductors, commented, "I am delighted that the use of our current limiter has generated so much interest and that so many people decided in favor of our product."
Source:
"Nexans wins Energy Master Award 2010 for its Superconducting Current Limiter"
Nexans press release (April 1, 2010)
http://www.nexans.com/eservice/Corporate-en/navigatepub_142482_-25031/Nexans_wins_Energy_Master_Award_2010_for_its_Super.html

Superconductor Technologies Inc. (May 18, 2010)

Superconductor Technologies Inc. (STI) has received the MICO "Bright Lights Innovation Award" in recognition of its potentially disruptive and market-changing intellectual property (IP). The award was presented at MDB Capital Group's inaugural Bright Lights Conference, which showcased 50 of the most innovative public companies ranking in the 90th percentile for technology leadership from among over 1,600

small cap companies that have been granted U.S. patents. Jeff Quiram, STI's president and chief executive officer, commented, “We are making solid progress on our strategy to align our IP and HTS material deposition processes with our volume manufacturing expertise to enter attractive new global markets. We are honored to receive the MICO award, which recognizes our significant IP capabilities.”
Source:
“STI Receives MICO Innovation Award at MDB’s Bright Lights Intellectual Property Conference”
Superconductor Technologies Inc. press release (May 18, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1428213&highlight

Power

American Superconductor Corporation (April 1, 2010)

American Superconductor Corporation (AMSC) has received an order from Vestas Australian Wind Technology Pty Ltd. for a large D-VAR-based grid interconnection system consisting of 24 D-VAR modules integrated with external smart-switched capacitor banks and proprietary AMSC controls. The order is the largest order for a grid interconnection system that AMSC has received to date. Vestas intends to use the system to meet local grid interconnection requirements for a 206 MW wind farm that is being constructed in Western Australia; upon completion (by the end of 2011), the wind farm will be larger than any wind farm presently operating in Australia. The equipment is scheduled for delivery within 12 months. Timothy Poor, Senior Vice President of Global Sales and Business Development at AMSC, commented, "Australia was among the first countries to adopt dynamic voltage control requirements for wind farms connecting to the utility grid. We expect that additional countries around the world will adopt similar strict dynamic voltage control requirements to more effectively control power flows stemming from the utility-scale wind farms and solar power plants that are being installed around the world. This, in turn, will help expand our addressable market." The D-VAR system ordered by Vestas will be the eighth system from AMSC to be deployed in Australia; together, these systems are responsible for connecting nearly 600 MW of wind power to Australia’s power grid, representing more than one-third of the country’s present wind power capacity.
Source:
“AMSC Receives Its Largest Grid Interconnection System Order to Date”
American Superconductor Corporation press release (April 1, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1408854&highlight

American Superconductor Corporation (April 6, 2010)

American Superconductor Corporation (AMSC) has received an initial order worth more than US $20 million from Ghodawat Energy Pvt. Ltd. (GEPL, India) for the supply of full wind turbine electrical control systems. Delivery of the control systems is scheduled to begin during the middle of the present calendar year and will be completed by the end of calendar year 2013. The order is the sixth volume production order for wind turbine power electronic components or systems that AMSC has received in the last 12 months. GEPL has begun manufacturing doubly fed induction wind turbines that were designed by and licensed from AMSC Windtec™, a wholly owned subsidiary of AMSC. Greg Yurek, AMSC founder and Chief Executive Officer, commented, "In India, wind power is projected to continue to account for an increasing percentage of the country's energy mix. Ghodawat is capitalizing on this opportunity by producing towers, developing wind farms and - now - manufacturing and deploying entire wind turbine systems. With its years of industry experience and proven wind turbine technology from AMSC, we believe Ghodawat is positioned to be a

winner in the market." GEPL recently completed the construction of a wind turbine production plant with an estimated annual output of 500 MW.
Source:
"AMSC Receives $20 Million Order for Wind Turbine Electrical Control Systems from India's Ghodawat Energy Pvt. Ltd."
American Superconductor Corporation press release (April 6, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1409747&highlight

SuperPower (April 6, 2010)

SuperPower and the University of Houston have completed two licensing agreements covering intellectual property (IP) rights for the continuation of SuperPower's development efforts in the area of second-generation HTS wire. The first agreement covers IP for new developments in 2G HTS wire presently covered under a Sponsored Research Agreement (SRA) between the two parties. The second agreement covers a fundamental composition of matter patent for high-temperature superconductors, discovered by Paul Chu at the University of Houston in 1987. Arthur P. Kazanjian, general manager of SuperPower, commented, "For the past several years we have partnered closely with the Texas Center for Superconductivity and the University of Houston on our wire development efforts. The execution of both the Sponsored Research Portfolio License Agreement and the Chu Patent License Agreement with the university enables SuperPower to continue to advance in the development of world-class 2G HTS wire for a broad range of applications by providing rights to the basis intellectual property in the field." In 2009 SuperPower separated its continuing wire developmental program from its manufacturing operation, with five scientists and engineers working under the direction of Dr. Venkat Selvamanickam at the University of Houston and the manufacturing organization and company headquarters remaining in Schenectady.
Source:
"SuperPower and the University of Houston Sign High-temperature Superconductor Wire Licensing Agreements"
SuperPower press release (April 6, 2010)
http://www.superpower-inc.com/content/superpower-and-university-houston-sign-high-temperature-superconductor-wire-licensing-agreem

Zenergy Power plc (April 14, 2010)

Zenergy Power plc has successfully completed the development of a high-speed ink jet printing process required for the low-cost production of its second-generation HTS wire. Together with the recent qualification of Honeywell Specialty Materials as an industrial supplier, this achievement marks the end of the R&D phase; once qualification of the industrial supply of metal tapes from ThyssenKrupp VDM GmbH has been completed (during the second half of 2010), Zenergy will commence the industrial scaling of its production of second-generation HTS wires. The new high-speed ink jet printing process will enable significant cost savings by significantly increasing the speed at which active chemical layers can be applied to metal substrates (reducing processing times and increasing output), enabling a more consistent application of chemical layers (improving wire quality and reducing scrap rates, which in turn will increase production yields and lower costs), and enabling consistent chemical layers to be applied to wider metal tapes (significantly increasing production volumes). This process, once scaled, should enable the production of the lowest-cost superconductor wire available, which in turn will be even cheaper than traditional copper wire.
Source:
"2G Development Milestone Ink Jet Processing and Continuous Wire Processing"

Zenergy Power plc press release (April 14, 2010)
http://www.zenergypower.com/images/press_releases/2010/2010-04-14-2G-Development-Milestone.pdf

Nexans (April 19, 2010)

Nexans, Endesa S.A. (a Spanish energy provider), and the ICMAB-CSIC Institute for Materials Sciences have reported the successful conclusion of the Endesa Supercable project, which set a new world record: in December 2009, the single-phase, medium-voltage cable (24 kV) carried a current of 3,200 A under laboratory conditions, almost 10 % higher than any installed medium-voltage cable worldwide. During ten load cycles of 24 hours, the rated current was applied for 8 hours per cycle while continuously subjecting the cable to twice the nominal voltage. The cable successfully withstood various test protocols involving varying loads and voltages exceeding the nominal value. As a next step, the project partners are planning to install the 30-m long demonstration cable, along with its associated terminations and cryogenic equipment, in a power grid.

Source:
“Superconducting medium voltage cable from Nexans conducts record current: 3,200 amperes during load cycle tests”
Nexans press release (April 19, 2010)
http://www.nexans.com/eservice/Corporate-en/navigatepub_142482_-25272/Superconducting_medium_voltage_cable_from_Nexans_c.html

American Superconductor Corporation (April 21, 2010)

American Superconductor Corporation (AMSC) has received another follow-on order for 30 sets of wind turbine power electronic components from Hyundai Heavy Industries Co., Ltd. (HHI, South Korea). The components will be used in 1.65-MW wind turbines designed by AMSC Windtec™, a wholly owned subsidiary of AMSC. AMSC expects to complete shipments for this new order by June 30, 2010. Greg Yurek, AMSC founder and Chief Executive Officer, commented, "With a strong business plan and flawless execution, HHI is building a vibrant, multi-national renewable energy business. This latest order is further evidence of the rapid traction the company's 1.65 MW wind turbines are gaining in the global marketplace. We look forward to continuing and strengthening our strategic alliance with HHI in the years ahead." HHI has already received orders for its 1.65-MW wind turbines from Korea, the United States and Pakistan.

Source:
“AMSC Receives Follow-on Wind Turbine Power Electronics Order from Hyundai Heavy Industries”
American Superconductor Corporation press release (April 21, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1415517&highlight

American Superconductor Corporation (May 13, 2010)

American Superconductor Corporation (AMSC) has announced its fourth quarter and full year financial results for fiscal 2009, ending March 31, 2010. Revenues for the fourth quarter increased by 43 % to US $87.6 million, compared with $61.2 million for the same period in the previous fiscal year. The gross margin for the fourth quarter was 37.8 %, compared with 32.6 % for the same period in the previous fiscal year. The net income and the non-GAAP net income for the fourth quarter were $4.9 million and $8.4 million, respectively, compared with $1.3 million and $4.1 million, respectively, for the same period in the previous fiscal year.

Revenues for full-year fiscal 2009 increased by 73 % to $316.0 million, compared with $182.8 million for full-year fiscal 2008. The gross margin was 36.4 %, compared with 28.4 % for fiscal 2008. The net income and the non-GAAP net income for the full year were $16.2 million and $31.7 million, respectively,

compared with $16.6 million and $3.1 million, respectively, for fiscal 2008.

Greg Yurek, AMSC's founder and chief executive officer, commented, "AMSC… set new records for revenues and gross margin in the fourth fiscal quarter, generated better-than-expected net income and closed a steady stream of large wind power and power grid orders. Entering fiscal 2010, we have approximately 90 percent of our forecasted revenues in backlog, which gives us a high degree of confidence we will grow revenues by more than 30 percent year over year. We also expect further increases in productivity in fiscal 2010. Coupled with our strong forecasted revenue growth, we expect these productivity gains will drive at least a 70 percent increase in non-GAAP earnings year-over-year. We expect that this growth in non-GAAP earnings will translate into net positive cash flow for the year even as we continue to invest aggressively for continued growth in future years."

As of March 31, 2010, AMSC had $155.1 million in cash, cash equivalents, marketable securities, and restricted cash and a backlog of approximately $588 million, of which more than $380 million should be recognized as revenue in fiscal year 2010.

Source:
“AMSC Reports Fourth Quarter and Full Year Fiscal 2009”
American Superconductor Corporation press release (May 13, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1426357&highlight

American Superconductor Corporation (May 17, 2010)

American Superconductor Corporation (AMSC) has received a new multi-year order worth approximately US $445 million from Sinovel Wind Group Co. Ltd. (Sinovel, China) for electrical components to be used in Sinovel’s 1.5-MW wind turbines. Shipments of the components are scheduled to being in early 2011 and will continue for a period of 30 months. AMSC is already shipping components to Sinovel under a multi-year contract that ends in early 2011. Greg Yurek, founder and chief executive officer of AMSC, commented, "We are proud to extend our strategic business alliance with Sinovel, which has proven consistently to be a leader in wind turbine technology. Since starting up production in 2006, Sinovel has grown more rapidly than any wind turbine manufacturer in the world. This new order will support Sinovel's continued production of SL1500s [the brand name for Sinovel’s 1.5-MW wind turbine]. At the same time, Sinovel plans to increase production of its 3-MW wind turbines, which are installed and operating in China's first offshore wind farm and also being marketed for onshore applications. In addition, Sinovel expects to install its 5-MW prototype by the end of 2010. These higher power systems, which Sinovel developed utilizing AMSC Windtec(TM) designs, are also equipped with AMSC's power electronics."

Source:
“AMSC Receives $445 Million Multi-Year Order From Sinovel Wind”
American Superconductor Corporation press release (May 17, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1427558&highlight

American Superconductor Corporation (May 25, 2010)

American Superconductor Corporation (AMSC) and Sinovel Wind Group Co. Ltd. (Sinovel, China) have announced an expansion of their strategic partnership to include additional wind turbine designs for both onshore and offshore applications. Under this agreement, AMSC Windtec™ (a wholly owned subsidiary of AMSC) will design and jointly develop a range of advanced multi-megawatt-scale wind turbines, which Sinovel plans to market and sell worldwide. Volume production of these turbines is expected to begin by the end of 2012. In addition, Sinovel will purchase the core electrical components for these machines from AMSC. At present, Sinovel is China’s largest wind turbine manufacturer and the third-largest wind turbine manufacturer in the world, based on market share.

超電導 Web21 Superconductivity
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Source:
"AMSC and Sinovel Expand Strategic Partnership"
American Superconductor Corporation press release (May 25, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1430702&highlight

Medical

Medical College of Wisconsin (April 5, 2010)

A collaboration among the Medical College of Wisconsin (Milwaukee), the Children's Hospital of Wisconsin (Milwaukee), University of Wisconsin-Madison, and the Hope Children's Hospital (Chicago) is using an ultrasensitive SQUID detector to measure the magnetic signals produced by fetal hearts to screen for rare but very serious fetal heart arrhythmias. The translational research problem is enabling pediatric cardiologists and obstetricians from around the U.S. to obtain additional data and to provide the best treatment options for their patients. The screening test is safe, non-invasive, and takes about one hour to perform. The SQUID detector has already been used to examine heartbeat irregularities in more than 300 patients. The team is now planning to construct a mobile detector that will require a smaller SQUID sensor, a special shield to block magnetic interference from the environment, and a truck large enough to carry the device. The unit is expected to be ready for testing within about one year.
Source:
"Ultrasensitive detector pinholes big problem in tiny fetal heart"
Medical College of Wisconsin press release (April 5, 2010)
http://www.med.wisc.edu/news-events/news/ultrasensitive-detector-pinpoints-big-problems-in-tiny-fetal-hearts/26976

TechPrecision Corporation (May 24, 2010)

TechPrecision Corporation, a manufacturer of large-scale, high-precision machined metal fabrications, has announced that one of its customers, Still River Systems, Inc., has successfully extracted a clinical beam from the first production unit of the world's smallest high-energy proton therapy accelerator. This achievement will enable the installation of Still River Systems' Monarch250 proton beam radiotherapy system at the Siteman Cancer Center (Barnes-Jewish Hospital and Washington University School of Medicine, St. Louis) to proceed. With this accelerator, Still River Systems plans to use the benefits conferred by superconducting technology to increase access to proton beam therapy, providing a cost-effective alternative to existing proton therapy systems. TechPrecision's wholly owned subsidiary, Rancor, Inc., has been collaborating with Still River Systems on the development of an efficient manufacturing process for producing the Monarch250 proton beam radiotherapy system and has an exclusive manufacturing and supply agreement with Still River Systems to provide key components. Upon FDA approval of the radiotherapy system, this agreement could generate approximately US $30 million in revenue for Rancor over the next three years.
Source:
"TechPrecision Corporation Announces Achievement of Important Product Manufacturing Milestone by Still River Systems, Inc."
TechPrecision Corporation press release (May 24, 2010)
http://www.techprecision.com/press_releases.html

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Quantum Electronics

National Institute of Standards and Technology (April 15, 2010)

Researchers at the National Institute of Standards and Technology have developed a single photon detector capable of counting individual photons of light travelling through fiber optic cables with an efficiency of approximately 99 %. The detector could enable improvements in electronic communication security, quantum computing and optical power measurements. Basically, the detector utilizes a superconductor to function as an ultra-sensitive thermometer. Individual photons hitting the detector increase the temperature, thereby increasing electrical resistance, by minute amounts; the detector registers these increases as indicating the presence of a photon. This methodology enables extremely low levels of light to be measured with great accuracy. The research team is presently developing evaluation techniques for measuring the detector's abilities, as all presently available methods are inadequate.
Source:
"NIST detector counts photons with 99 percent efficiency"
National Institute of Standards and Technology press release (April 15, 2010)
http://www.nist.gov/eeel/optoelectronics/detector_041310.cfm

National Institute of Standards and Technology (April 28, 2010)

Researchers at the National Institute of Standards and Technology have developed a "dimmer switch" for linking a quantum bit (qubit) and a quantum bus in a superconducting circuit. This control device, created from a radio-frequency SQUID, allows interactions between the above-mentioned components to be "tuned" from 100 MHz to nearly zero, potentially advancing the development of a practical quantum computer by allowing developers to flexibly control the interactions between multiple circuit elements in an intricate network. While other research groups have demonstrated switches for two or three superconducting qubits coupled together, the NIST switch is the first to produce predictable quantum behavior over time with the controllable exchange of individual microwave photons between a qubit and a quantum bus. The group's research was published in *Physical Review Letters*.
Source:
"NIST develops 'dimmer switch' for superconducting quantum computing"
National Institute of Standards and Technology press release (April 28, 2010)
http://www.nist.gov/eeel/quantum/qubit_042710.cfm

Communication

Superconductor Technologies Inc. (May 4, 2010)

Superconductor Technologies Inc. (STI) has announced its first-quarter fiscal results for the period ending April 3, 2010. Total net revenues increased to US $3.4 million, compared with $1.7 million for the same quarter in the previous fiscal year. The net commercial product revenue was $2.4 million, compared with $1.1 million for the same period in the previous fiscal year. Meanwhile, government and other contract revenue totaled $1.1 million, compared with $546,000 for the same period in the previous fiscal year. The net loss for the quarter was $2.5 million, compared with a net loss of $3.5 million for the same period in the previous fiscal year. Jeff Quiram, STI's president and chief executive officer, commented, "Our first quarter

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

revenues of $3.4 million were more than double the 2009 first quarter and reflect a more robust business environment compared to the same period last year. We are also encouraged by our backlog level at quarter end, as our wireless customers continue to focus on improving network performance… In addition, our 2G HTS wire initiative is progressing as planned. After successfully producing wire in one-meter lengths, we are now completing the design of our second-generation wire deposition machine, which will produce 50-meter lengths. We have established our initial product roadmap and are preparing our facility for 2G HTS wire production." As of April 3, 2010, STI had $8.5 million in cash and cash equivalents and a commercial product backlog of $724,000.
Source:
"Superconductor Technologies Inc. Reports First Quarter 2010 Results"
Superconductor Technologies Inc. press release (May 4, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1421772&highlight

Accelerator

Bruker Energy & Supercon Technologies Inc. (April 5, 2010)

Bruker Energy & Supercon Technologies Inc. (BEST) has received a contract worth $2.4 million from the Brazilian Synchrotron Light Laboratory (LNLS) for a turnkey beamline. The new beamline will be used for high performance X-ray absorption and diffraction experiments. Wolfgang Diete, Director of BEST's Synchrotron & Beamline Business, commented, "We are very proud that LNLS has selected BEST based on our technological experience and our good reputation for delivering state-of-the-art equipment at other synchrotron facilities worldwide on schedule and with excellent performance. This project is very important for LNLS and their user community, but also for our future business. Brazil has already started planning its next generation synchrotron facility for the growing demand for synchrotron radiation in the scientific community. We expect to establish a good partnership with LNLS which will qualify us for future projects as well."
Source:
"Bruker Energy & Supercon Technologies Awarded Contract by Brazilian Synchrotron Facility for Turn-Key Beamline"
Bruker Energy & Supercon Technologies Inc. press release (April 5, 2010)
http://www.bruker-est.com/pr100405.html

RI Research Instruments (April 21, 2010)

RI Research Instruments, a majority-owned subsidiary of Bruker Energy & Supercon Technologies Inc. (BEST), has been awarded a US $7.7 million contract from the U.S. Department of Energy's Brookhaven National Laboratory (BNL) for a turnkey 200-MeV electron injection linear accelerator (linac), which will be used in BNL's next-generation National Synchrotron Light Source (NSLS-II). The contract includes the engineering, manufacturing, integration, delivery, installation, and commissioning of the linac. Delivery of the linac to BNL is scheduled to occur in January 2012. The construction of the NSLS-II itself is expected to be completed in 2015 and will be capable of producing X-rays that are more than 10,000 times brighter than the current NSLS. Dr. Michael Peiniger, Managing Director of RI Research Instruments, commented, "This award represents the continuation of our business in linear electron accelerator systems and particle accelerating products worldwide. Similar electron linear accelerators have been supplied to major research laboratories in Switzerland, Great Britain, Australia, Germany and are under production for

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Taiwan and The Netherlands. We are very pleased to have been selected by BNL for the NSLS-II Project, which is expected to have world-leading performance."
Source:
"BEST Subsidiary RI Research Instruments Awarded $7.7M Linear Accelerator Contract from DOE Brookhaven National Laboratory"
RI Research Instruments press release (April 21, 2010)
http://www.bruker-est.com/pr100421.html

Basic

Rice University (May 28, 2010)

Dr. Qimiao Si and colleagues at Rice University, Zhejiang University (China), the University of California at Los Angeles (UCLA), Los Alamos National Laboratory, and the State University of New York at Buffalo (SUNY-Buffalo) have reported new evidence of the quantum features of pnictides, providing insight into the mechanism of high-temperature superconductivity. Dr. Qimiao Si at Rice, explained, "In correlated electron systems like the pnictides and their parent compounds, the electrons are caught in a competition between forces. On the one hand, they are compelled to move around, and on the other, they are forced to arrange themselves in a particular way because of their desire to repel one another. In this study, we varied the ratio between these competing forces in an effort to find the tipping point where one takes over from the other." To examine what occurs when the kinetic energy is decreased by expanding the distance between atoms in a material's lattice, the group used iron oxychalcogenide, which is a layered material with a pattern similar to that of iron pnictides but with a larger distance between iron atoms. Subsequent testing confirmed the group's theoretical predictions, i.e., that a slight expansion of the iron lattice pushed the system into a Mott insulating state. These results provide further evidence that undoped iron pnictide parent compounds are on the verge of Mott localization. The group's research was published online in the journal *Physical Review Letters*.
Source:
"Zeroing in on quantum effects"
Rice University press release (May 28, 2010)
http://www.media.rice.edu/media/NewsBot.asp?MODE=VIEW&ID=14345

(Published in a Japanese version in the July 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
超電導 Web21 Superconductivity
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Development of industrial superconducting devices - Trends in industrial superconducting-device technology -

Hiroyuki Ohsaki, Professor
Graduate School of Frontier Sciences
The University of Tokyo

While various types of superconducting devices have been developed aiming at applications in a wide range of industrial fields, this paper focuses on superconducting rotating machines whose research and development has been widely promoted recently. Initially, high-temperature superconducting motors attracted attention because it was thought to be a promising technology for reducing electrical loss of motors which consume more than 60 % of the industrial electric demand. The possibility of the application of superconductivity technology to large-scale motors mainly used for pumps and fans was investigated and the research and development was centered mainly in USA. Then, the target moved to low-speed, large-torque motors used for propelling ships, and the development and tests of large-scale motors were conducted mainly in USA and Germany. Compared to such world trends, activities in Japan were rather slow and research was limited to small scales; however, in the past several years, research and development centering on marine motors has been promoted by industry-university cooperation. In the past few years, especially, a group mainly consisting of Kawasaki Heavy Industries and Tokyo University of Marine Science and Technology is promoting research and development. The Kyoto University group, which has been continuing research and development of superconducting motors for electrical vehicles, has now entered full-scale stage and demonstration tests are scheduled in several years. Furthermore, research and development of a wind generator, which is an ultra-low, large-torque rotating machine, has become active domestically and globally. This rotating machine has broad utility from small-scale to large-scale, such as a turbine generator. Although the development is centered on rotating machines for transportation systems and wind generators, it will expand to the sophistication of elemental technology for other rotating machines as the technical development proceeds resulting in the improvement of technology leading to practical use. Thus, the application fields will be expanded with further technical development in the future, and it is expected that the initial target of applications to driving motors for pumps and fans become possible.

For the industrial superconducting equipment to be accepted in the market, it is necessary to set an appropriate target for the development of devices that match the market needs and to verify and demonstrate the technology. It goes without saying that improvement in cost effectiveness, cost reduction of refrigerators and refrigerating systems, improvement in reliability, and reduction of maintenance cost are required. For practical use, it is necessary to first apply to DC superconductivity so that applications that make use of the characteristics of DC superconducting technology such as high magnetic field and large current are utilized. Induction heating of Zenergy Power and Bültmann, which was announced about five years ago and has already been commercialized, is a typical example of successful industrial equipment, although it is a special one. In addition, practical use of superconducting magnetic separators is being developed steadily. It is also possible that high-temperature superconductors are used in the future for silicon single-crystal pulling apparatus to which superconducting magnets have already been applied.

Meanwhile, as for the superconducting maglev train, which is being intensively developed aiming at commercial service in 2025, Maglev Practical Technology Evaluation Committee of the Ministry of Land, Infrastructure, Transport and Tourism held on July 28, 2009 appraised that technologies necessary for commercial line have been systematically and exhaustively developed so that it has become possible to

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

concretely establish detailed specification for commercial line and technical standard. Furthermore, Central Japan Railway Company and Japan Railway Construction, Transportation, and Technology Agency have submitted an investigation report on the construction cost and transportation demands for Chuo Shinkansen (between Tokyo and Osaka) on December 24, 2009. According to this report, the distance of the line is 438 km with a required travel time of 67 min, construction cost is about ¥9,000 billion, and annual maintenance and operation cost is about ¥300 billion for the South Alps Route, which is the shortest of the three candidate routes. In addition, Central Japan Railway Company announced on January 25, 2010 that it intends to participate in overseas high-speed railway projects including in USA to promote the evolution of superconducting linear system. Attention is also being focused on the introduction of high-temperature superconducting magnets.

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Technical development of industrial superconducting devices

- Progress in technical development of superconducting motors for electric vehicle -

Taketsune Nakamura, Associate Professor
Graduate School of Engineering
Kyoto University

An academic-industry group, the leader of which is the author, is challenging research development to use High-Temperature Superconducting Induction-Synchronous Machine (HTS-ISM)[1),2)] for electrical vehicles[3),4)]. This research and development project is being conducted as part of "Development of Energy-saving Innovative Technology" sponsored by NEDO. The project is commissioned to Kyoto University and Aisin Seiki Co., and IMRA Material R&D Co., Niigata University, and Research Institute for Applied Sciences have joined the research group. This paper introduces the outline of the above-mentioned research and development.

The four main targets of this project are: research and development of high-efficiency, high-power-density HTS-ISM for vehicles; development of optimum driving technology; development of small-scale, high-efficiency, non-sliding refrigerator; research development of structure and system of refrigeration for small-scale rotating equipment. The purpose is to realize a commercial next-generation, magnet-less driving system integrated with a refrigerator using a high-temperature superconducting wire, that is, a high-temperature superconducting wire that can be commercially produced or whose mass production is expected. It is targeted to demonstrate a driving system that satisfies specification required for vehicles in a visible manner. Assuming a middle-class electric vehicle whose introduction will bring about a large impact, the maximum output of 100 kW is required. As described in the commentary of the author[5)], it is necessary to realize the revolutionary merit of the use of high-temperature superconductivity even if the loss of the cooling system is taken into consideration. By realizing the following two targets, this project will achieve massive improvement in energy saving compared to conventional motors (IPM motor*, which is widely used in Japan, and induction motor, which is widely used in USA and Europe).

(1) High efficiency for variable-speed driving.
(2) High torque density.

As for target (1), while vehicles have various driving modes and torque, and the speed transmitted to the axle vary momentarily, the total efficiency for such variable-speed driving must be improved. The "variable speed" referred to here is different from the concept used when discussed from the viewpoint of a general energy-saving effect. Here, the variable-speed driving that provides energy saving (such as damper control of large-scale blower) is not pursued. In order to achieve high efficiency under restrictions of the variable speed required by the driver, it is necessary to note that the direction of research and development is somewhat different from general variable-speed driving. Although the logic that use of superconductivity for rotating equipment leads to reduction in copper loss thereby resulting in high efficiency of single rotating equipment is correct, scale merit is usually taken into account by assuming a class ranging from several hundred kW to MW. If high torque density, according to target (2), is realized, the conventional transmission gear, which is essential for the existing driving system of vehicles, becomes unnecessary. Elimination of transmission in the driving system results not only in weight saving in the car body but also in the disappearance of gear loss that provides higher efficiency even when the cooling loss of refrigerator is taken

*Interior Permanent Magnet

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

into account. Thus, it is expected that the variable speed, high-efficiency driving system of so-called direct driving achieves ultimate energy saving without using magnet.

Figure 1 shows an example of efficiency map of HTS-ISM of 50-kW class investigated on the basis of non-linear equivalent circuit[6]. The data in the figure were taken from an IPM of size and output[7] comparable to those of the second-generation Prius® (Toyota Motor Corp.) and it is seen that very high efficiency is obtained for a wide range of torque and rotating speed. In particular, the high efficiency in constant-torque mode at low speed is a characteristic that cannot be obtained even with IPM motors[7]. Furthermore, the maximum torque reaches 1600 N m. Although the above-mentioned values for the IPM motor of the second-generation Prius® (nominal maximum torque: 400 N m) is obtained through a gear, the torque value of HTS-ISM is achieved with the motor shaft, which clearly indicates that direct driving is quite possible. Since the second-generation Prius® is a hybrid vehicle, the driving operation based only on electricity is limited and so, it is not possible to make precise comparison for electrically driven motor for vehicle. However, since detailed data are available for the rotating equipment, the data were used for the investigation. Basically, it is necessary to compare with a motor used for genuine electric vehicle, which is now under investigation.

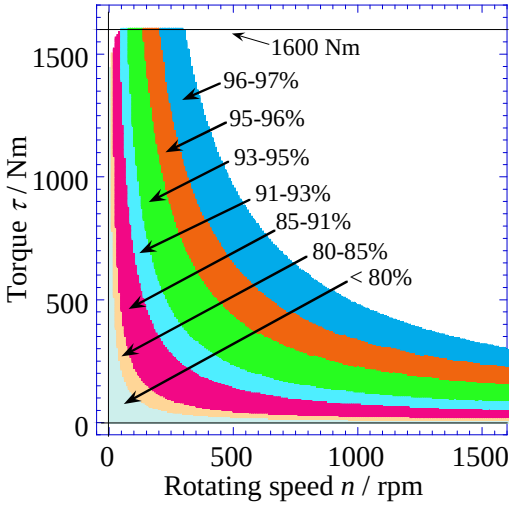

Fig.1 Example of analysis of efficiency map for HTS-ISM of 50-kW class[6]

Figure 2 shows a schematic diagram of a direct-driving-vehicle system provided with HTS-ISM. The research and development project is now being promoted energetically to realize such a system.

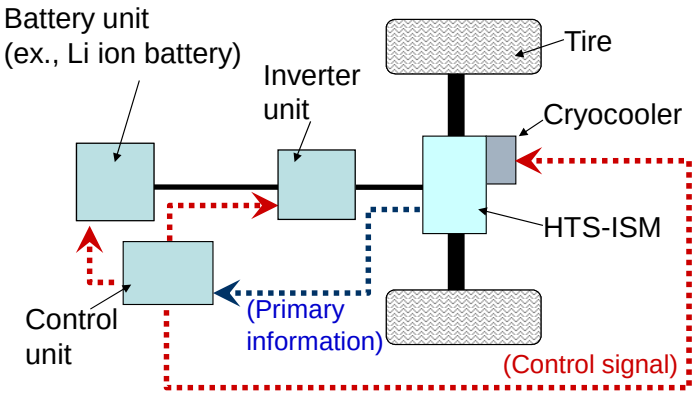

Fig.2 Example of direct-driving-vehicle system provided with HTS-ISM

Reference:

1) Taketsune Nakamura, "Development of superconducting squirrel-cage induction/synchronous motor," Superconductivity Web21, March 2007, pp. 7-8
2) Taketsune Nakamura, "Feature Articles: Progress in industrial superconducting equipment technology:

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Overview of high-temperature induction/synchronous motor technology," Superconductivity Web21, March 2008, pp. 3-4
3) Nippon Keizai Shimbun, "Challenge to 2030, Next-generation industrial technologies, High-temperature superconducting materials ②," June 10, 2009, p. 9
4) Nippon Keizai Shimbun, "Development of superconducting motors for electric vehicles is being accelerated," November 30, 2009, p. 12
5) Taketsune Nakamura, "Past, present, and future of superconducting motors ①," Superconductivity Web21, February 2010, pp. 22-23
6) T. Nakamura, T. Nishimura *et al*., to be submitted to Superconductor Science and Technology
7) R. H. Staunton *et al*., "Evaluation of 2004 Toyota Prius Hybrid Electric Drive System", U.S. DEPARTMENT OF ENERGY, Under contract DE-AC05-00OR22725 (2006)

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Development of industrial superconducting device technology
- Present status of technical development of superconducting marine motors -

Mitsuru Izumi, Professor
Faculty of Marine Technology
Tokyo University of Marine Science and Technology

Since a prototype of a motor using trapped magnetic flux of yttrium-based high-temperature bulk superconductor prepared by melt growth was produced, a motor using bulk superconductor applied to field pole has been produced and motors with bismuth-based high-temperature superconducting wires wound around the iron core of the field circuit and the armature have been developed in Japan[1)]. Meanwhile, a prototype of a motor consisting of a coreless superconducting coil, which provides a magnetic field without winding around an iron core and through which large current is passed, has been produced[2)]. The results of the load test of a marine motor of 36.5 MW have been published in USA, and rotating machine of MW class or larger for ship propulsion in which the merit of introduction of superconducting motors is expected to be high are being developed in Japan as well as in Europe and Korea. These facts indicate that the stage of "demonstration of superconducting materials and wires" is making a transition to the stage of "demonstration of realization of superconducting motors as industrial superconducting equipment[3)]." It is also necessary, therefore, to clarify the portfolio of superconducting materials (bulk and wire) regarding diversified motors in the future.

Considering the social situation surrounding the marine business, such as the fluctuation of crude-oil price and global-warming issues, the sea transportation industry is under pressure to improve fuel cost and take measures for GHG (Greenhouse Gas) and exhaust gas regulation. Consequently, the development of global-environment-friendly Ecoship that uses natural energy such as solar energy and fuel cells is being appealed[4),5)]. Promising technologies required by the market include new fuel and generating plant as well as contra-rotating propellers for improving propeller efficiency. In the future, further improvement in the efficiency of the propulsion system is required taking into consideration elements such as ship maneuverability, exhaust-gas regulation, economical efficiency, and energy saving.

It is expected that the day when superconducting motors are used in ship propulsion system is not far if high efficiency, durability of coil, reliability, and maintainability as well as low cost are cleared. Since propulsion system is the vital part of the ship in sea, it must be noted that a robust and an breakable system, even if it is clunky, as well as tolerability to load fluctuation are required[6)].

Reference:

1) http://www.ihi.co.jp/ihi-ism/techno/motor1.html
2) http://www.jrtt.go.jp/business/research/seika/data/h20-02b.pdf
3) Proc. of EUCAS2009, J. of Phys., Conference Series, in press.
4) http://www.nyk.com/release/5/NE_090416.html
5) http://www.mol.co.jp/ishin/carcarrier/future/index.html
6) http://nippon.zaidan.info/seikabutsu/2003/00390/mokuji.htm

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Development of industrial superconducting device technology
- Present status of design technology of superconducting rotating machines for wind generation -

Hiroyuki Ohsaki, Professor
Graduate School of Frontier Sciences
The University of Tokyo

Under the circumstance in which effective use of natural energy is strongly required for the settlement or alleviation of environmental issues represented by global warming, application of wind-power generation is increasing globally. The maximum output of the present wind-power generation is about 6 MW and an increase in output is being investigated in order to obtain scale merit. However, it is very difficult to increase the output based on conventional technology because the weight of the generator (including the speed-up gear) increases significantly. Therefore, it is hoped that the construction of large-scale wind power generator of 10-MW class is made possible by using superconducting technology, and research and development is being promoted.

In the designing of wind-power generator, designing of electromagnetic field, designing of mechanism and structure, and thermal design are important as in the case of other superconducting devices. When a direct-drive wind-power generator of 10-MW class is assumed, for example, the rated number of revolution of windmill is about 10 rpm and the generated torque reaches about 10 MN. The torque tube that transmits a torque of 10 MN with excellent heat insulation is a very important component. Therefore, it is important to improve and establish technologies for designing of electromagnetic field making the most of the light weight and compactness of superconducting equipment and for designing of mechanism and structure corresponding to the torque by taking into consideration the support structure for electromagnetic force, and for the thermal designing that cools and insulates the rotating machine effectively. In addition, refrigerating system, electric power converter, and equipment for linking to electric-power network are also important for the power-generating system.

In the world, Converteam seems to be at an advanced stage in the designing of 8-MW wind-power generator, through development of elemental technologies for the development of the generator. AMSC of USA has designed a generator with an output of 8 to 10 MW. The designed generator of 8 MW has an outside diameter of 5 m, length of 3 m and weight of 120 to 140 tons, which indicates that the design has a significant merit of weight saving. Danmarks Tekniske Universitet (DTU) has designed a generator of 10 MW, whose design parameters are: 4.7-m outside diameter of the generator, 20-K operating temperature, 16 poles, and 9.1-T maximum experienced magnetic field.

In Japan too, a superconducting power generator with a characteristic structure targeting at wind-power generator of 10 MW has been recently proposed, and designing and research are being promoted. A group from University of Tokyo and Chubu Electric Power Co., including myself, has proposed a superconducting power generator consisting of a superconducting magnetic field provided by a simple-shaped circular pancake coil called the “increased lateral magnetic flux density” type. A group from University of Tokyo and Nippon Steel Corp. is searching for the possibility of superconducting field magnet using both superconducting coil and bulk. A group from Niigata University, Yokohama National University, and Chubu Electric Power Co. is studying a type in which the field coil on the rotor side is divided into two parts in the radial direction and the armature winding (stator side) is put in the gap, and a type in which the armature

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

winding is placed on both sides of the field coil. Since software for analyzing electromagnetic field has made remarkable progress recently; this is very helpful for designing of superconducting rotating machines because magnetic-flux density distribution, generated electromagnetic force and torque, and power generation characteristics can be analyzed in detail using two-dimensional or three-dimensional models. In the future, it is necessary to promote mechanical design, structure design, and thermal design in detail.

In Japan, although a turbine generator of 200-MVA class was designed and a prototype of 70-MVA was designed, manufactured, and tested as a reduced-size model under Super-GM Project, a large project for high-temperature superconducting power generator has not been carried out. Therefore, significant progress in the research and development stage for designing of superconducting rotating machines, improvement in fabrication technology, and acceleration of practical use is strongly desired.

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Development of industrial superconducting device technology
- Status of dissemination of superconducting magnetic separator -

Shigehiro Nishijima
Graduate School of Engineering
Osaka University

Superconducting magnetic separation is attracting attention as a new method for wastewater treatment. A treatment system for wastewater from drum cleaning was developed in March 2009. In September 2009, a recovery unit for cleaning agent used for restoration of polluted soil with Chlorinated Volatile Organic Compounds (hereinafter referred to as C-VOC) was developed. In addition, other magnetic separators are being developed, whole picture of which will gradually become open. This paper introduces the above-mentioned two cases.

Nippon Sheet Glass Engineering Co., Ltd. developed a magnetic filter for purifying drum-cleaning water subsidized by the Ministry of the Environment, and demonstrated it at Kansai Drum Center Joint Business Cooperatives.

There are two states of drums: unused drums and recycled drums, which are cleaned used drums. Although new drums are inexpensive and economic, used drums containing waste may cause environmental problems, such as emanation of polluted materials to soil or rivers due to open space storage. Therefore, it is desirable to recycle the drums after cleaning them. However, the cleaning water for recycling again causes trouble with its treatment, which is now handled as industrial waste. Since mainly the drums used by chemical companies, petroleum companies, food companies, and pharmaceutical companies are cleaned, the wastewater of cleaning is mixed wastewater containing various oils and chemicals and the purifying treatment is difficult. Consequently, the wastewater is treated as industrial waste and sewage water. Appropriate treatment of such wastewater for recycling will not only contribute to environmental conservation but also bring about economic merit by reducing the amount of industrial water use. The magnetic separator has been developed with such a background.

In the system, contaminants in the cleaning wastewater (hereafter referred to as COD) are flocculated together with fine ferromagnetic particles in the magnetic seeding machine and then, passed by magnets to filter the flocculants. Therefore, the system consists of a magnetic seeding machine, magnetic separator using permanent magnets, and magnetic filter using a superconducting magnet. It has become possible to treat 40 tons of wastewater per day using the system, thereby reducing the COD to less than 100 ppm.

Kajima Corp. has developed a method to effectively treat C-VOC in the groundwater and put into practice a method to effectively recover the iron powder used in the method making use of superconducting magnetic separator in cooperation with MS Engineering Ltd. C-VOC mixed with groundwater is difficult to dissolve in water and remains as a contaminant in the ground water for a long time. Therefore, EnviroJet Method was developed in which in-situ purification of C-VOC contamination is implemented. In this method, iron powders that decompose C-VOC are injected into the ground using high-pressure water jet to be mixed with the soil and clean it. The method had a disadvantage that part of the iron powders injected into the ground was discharged on the ground together with the discharged mud. It has become possible to recover almost 100 % of the iron powders contained in the discharged mud using a superconducting

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

magnetic separator. While the iron powders in the discharged mud could not be utilized because they could not be recovered, it is now expected that the cost of purification is reduced by about 10 % by recycling the iron powders in the discharged mud. The magnetic separator, which is an iron-powder recovering device using a high-gradient superconducting magnetic separator, has been developed in cooperation with MS Engineering Co. and it has been confirmed that the recovered iron powders can be reused.

(Published in a Japanese version in the March 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Overview of superconducting wire technology - Progress in medium and high magnetic field I_c technology for Y-based wires -

Masateru Yoshizumi, Associate Director
Superconducting Tapes & Wires Division, SRL/ISTEC

The applications of Y-based wires are expected in various magnetic fields such as in motors, transformers, SMES, and NMR, and high I_c in magnetic field is strongly desired from the viewpoint of practical use. To increase I_c value in magnetic field, it is effective to improve the J_c characteristics in magnetic field by introducing defects generated by heavy-iron irradiation or non-superconducting phase such as BZO as artificial pinning sites into superconducting phase. This paper outlines the recent progress in the development of a process for introducing artificial pinning sites.

SuperPower of USA, which is developing YGdBCO wires prepared by MOCVD method and leading the development of long wires in the world, tried to improve characteristics in magnetic field by introducing BZO as nanorods and obtained I_c^{min} = 186 A/cm at 77 K and 1 T for short wires and I_c^{min} = 50 A/cm or higher at 77 K and 1 T at both ends of long wire of 50 m.

LANL of USA tested multiple materials and various combinations of them by PLD method and found conditions for the minimum J_c^{max}/J_c^{min} ratio by combining a layer introduced with BZO nanorods and a layer introduced with Y_2O_3 nanodots. The absolute value of J_c^{min} becomes maximum in a film introduced only with BZO nanorods. The maximum value of I_c^{min} in last August was 234 A/cm at 75 K and 1 T. The value of I_c in self-magnetic field, although at 75 K, was 1006 A/cm showing very high characteristics even in self-magnetic field. Fujikura Ltd. of Japan also improved the characteristics of the long wire and obtained values exceeding 40 A in a long GdBCO wire of 90 m at 77 K and 3 T.

In the MOD method, wires prepared by ISTEC by introducing BZO nanorods showed the highest I_c characteristics of I_c^{min} = 115 A/cm (760 A/cm at sf) at 77 K and 1 T. AMSC of USA obtained a characteristic of 78 A at 75 K and 1 T using YDyBCO, which is a mixed crystal system, and they are now investigating further improvements in the characteristics by the introduction of BZO nanoparticles.

In addition to the above-mentioned introduction of artificial pinning centers, improvement of the substrate being developed by ORNL of USA is worth mentioning as a unique method. In this method, it is targeted to control the position and distribution of pinning centers represented by nanorods by improving the surface quality of the substrate by coating and firing MOD materials with two separated layers.

Since the magnetic field for measuring characteristics varies according to research institutes, it is difficult to make simple comparison of I_c characteristics in the magnetic field. However, it has been clarified that effective magnetic field and temperature differ according to the size and density of pins, and it is expected that evaluation is made on the basis of the targeted application environment in the future, which will result in further difficulty in comparing investigation. Furthermore, since it is possible that the optimum introduction methods for pinning centers, it seems important to promote effective research and development while collecting domestic and overseas information by seizing every opportunity and taking into consideration the status of the development.

(Published in a Japanese version in the April 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
超電導 Web21 Superconductivity
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Overview of superconducting-wire technology - Present status of high-speed fabrication of high-performance products of Y-based wires -

Yasuhiro Iijima, Group Leader
Superconductivity Project Team
Fujikura Ltd.

The development of Y-based superconducting wires has consistently adhered to the concept of wires with thin tape structure treated with highly oriented structure control from the viewpoint of material science. However, plastic-forming processes such as extrusion and wire drawing generally used for the production of electric wire and optical fiber are not effective; so, it is a problem to be solved to practically mass-produce products of long length at low cost and maintain a high performance. Several processes based on chemical vapor deposition and baking of the coated solid-phase have been investigated in parallel, and the technology is reaching a stage of mass-production due to the long-term investment owing to national projects and advancement in various vacuum technologies. It is expected very soon that commercialization will start in both Japan and USA using different processes.

Most of the present Y-based wires have a width of 4–5 mm and a cross-sectional area of 0.5–1 mm^2, and since the thickness of superconducting layer is about 1–2 μm, the ratio of area occupied by superconducting materials is about 2–3 % or lesser in the cross-sectional area. The current-carrying performance of the wire depends on the thickness of the superconducting layer. Recently, Hot-Wall Method, which provides precise temperature control in film-forming process, has been developed using pulse-laser deposition (PLD) method, which is a type of vapor-phase synthesis such that a high-performance film up to 4–6 μm can be accurately reproduced[1)]. Consequently, the I_c value of a short sample with a width of 1 cm reached higher than 1000 A and that of a 170-m-long sample reached 645 A in the self-magnetic field at 77 K. In addition, a value of 40 A or higher has been obtained in a magnetic field of 3 T perpendicular to the substrate. Therefore, long wires with the I_c value exceeding 300 A are now in view assuming a high-temperature magnetic-field environment of 50 K and 5 T. The advancement in the above-mentioned film-forming temperature-control technology significantly improved the longitudinal uniformity, and in the Hot-Wall PLD method, samples with I_c value fluctuation within 2 % over the whole length of 100 m can be produced with an excellent reproducibility[2)]. The fact that a superconducting film with a long length can be fabricated under fixed operating conditions without frequent adjustment indicates that conditions required for an industrial process are being established.

The intermediate layer of Y-based wires used to be relatively thick before forming the superconducting layer and the manufacturing wire speed of this process caused cost problem. However, the technology to reduce the thickness made great progress so that the process is not a rate-limiting factor any more. Above all, the intermediate layer in the IBAD method, for which high-strength metal substrate can be used, highly oriented substrate can be formed at a speed of several hundred m/h by using MgO of about 10-nm thickness as the oriented layer[3)]. In the superconducting–layer-forming process, recent improvement in laser optical source brought about rapid evaporation of raw material and the yield of deposition of the product has been increased to almost 60 %, thereby resulting in a fast-paced increase in the manufacturing wire speed of the PLD method. For a wire with I_c value of 300 A/cm per unit width (77 K, self-magnetic field), the speed exceeds about 100 m/h, thereby converting to a wire with 5-mm width, which provides a wire speed of mass-production level for superconducting film by vapor-phase synthesis together with the CVD process that have been developed in USA[2)]. Since the decrease in the manufacturing wire speed is

超電導 Web21 Superconductivity
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

inversely proportional to the thickness of the superconducting layer, performance and cost are in a trade-off relationship. However, it is expected that improvement in performance for the future continues for the time being because J_c value is increasing year by year due to the recent advancement in materials and processes including the use of Gd-123 film which has a relatively high critical temperature among the materials based on RE-123. Although required usage environment, performance, and cost differ according to the usage, higher performance at higher temperature and magnetic field continue to be pursued so that it is necessary to continue development with both the cost and the performance in view.

(Published in a Japanese version in the April 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Overview of superconducting wire technology - Progress in high J_C and low-loss technology of Bi-based wires -

Kazuhiko Hayashi
Superconductivity/energy Technology Development Division, Materials and Process Technology R&D Unit
Sumitomo Electric Industries, Ltd.

1. History of improvement of critical current

$(Bi,Pb)_2Sr_2Ca_2Cu_3O_y$ (Bi2223) high-temperature superconducting wires are fabricated using a method called PIT (Powder In Tube) method, in which precursor powder is filled in a metallic pipe, fabricated in a composite process, and then, the inner powder is sintered to obtain tape-shaped product with a width of about 4.3 mm and thickness of about 0.23 mm. In order to obtain flexibility, the superconducting filament, which is ceramic, has a multifilamentary structure covered with silver or silver alloys.

Figure 1 shows the history of the development of the critical current of Bi-based wires. In the initial stage up to 1995, the basic process of PIT method, in which composite with silver is applied, was established and prototype wires of 1-km class were fabricated. During this period, the fabrication process was improved resulting in gradual improvement in critical-current characteristics and 100 A was obtained with a standard size under self-magnetic field at liquid-nitrogen temperature. The reason why wire fabrication made great progress was the development of over pressure sintering technique. The over pressure sintering method brought about high production yield by significantly reducing local defects as well as with improvements in the critical current and mechanical strength realizing the level at which Bi-based wires can be called industrial products. Optimization and improvement of the process and conditions for manufacturing processes proceeded after that and critical value of 236 A was obtained for short samples (77.3 K, self-magnetic field) and 200 A was obtained for long wires of km class at mass-production level. It has become possible to supply wires with 160–180 A at an industrial level. An Index of long wires, I_c (4-mm-wide) × L (length), reached 368,242A m.

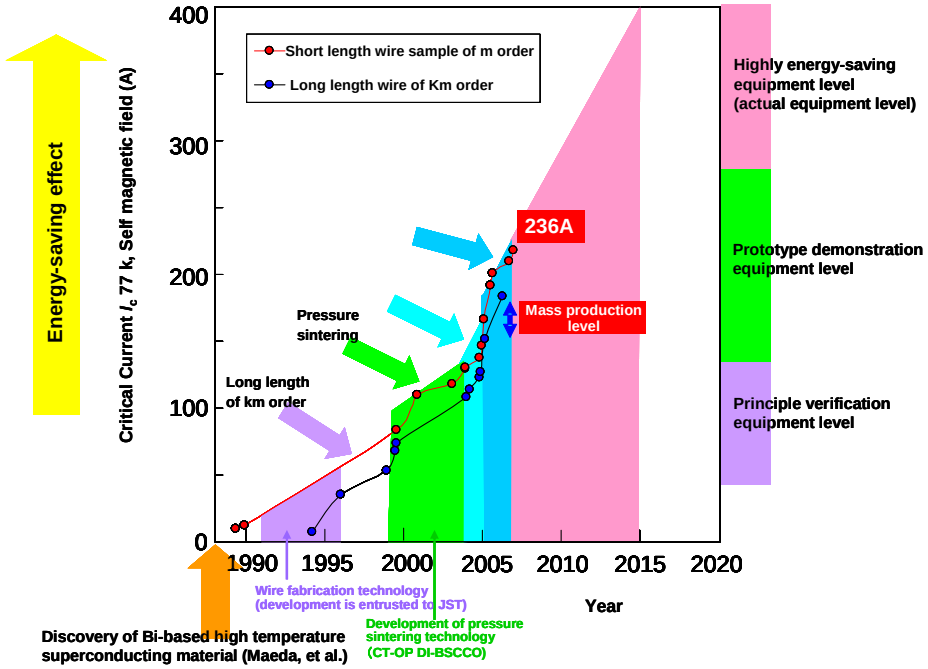

Fig. 1 Energy-saving effect

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

2. Prospect of future improvement

It is apparent that the advancement in critical-current characteristics so far has been done by improving crystal alignment. Figure 2 shows the relationship between the orientation and the critical-current characteristics evaluated by transmitted X-ray diffraction method using high-intensity synchrotron radiation of Spring-8. The use of Spring-8 enabled the non-destructive evaluation of the average orientation over the whole wire without peeling off the silver sheath. The half-value width of (200) reflection is 12.4° (the average deviation angle from the tape surface is 6.2°, which is half the half-value width) for wires of 200-A class, which indicates that there is room for improvement.

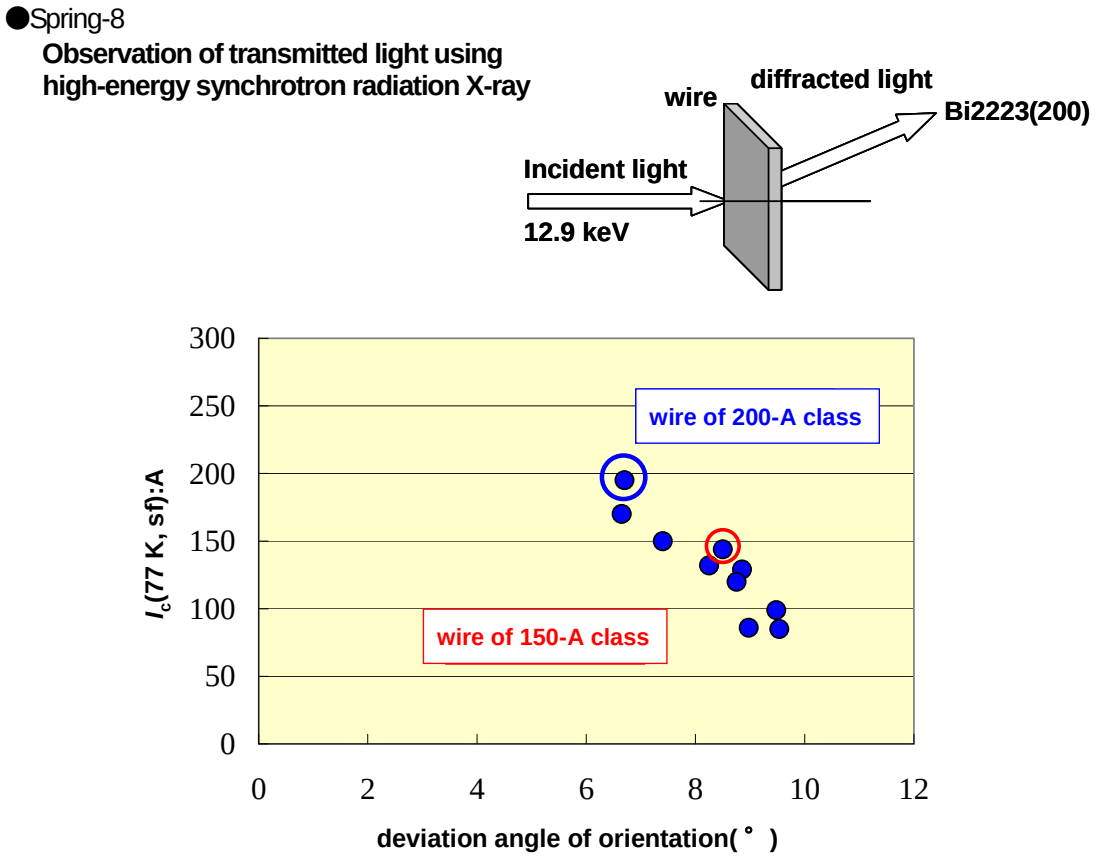

Fig. 2 Relationship between degree of crystal orientation and critical-current characteristics

Figure 3 shows the distribution of critical-current density in the width direction evaluated using Hall element[1]. In this method, the distribution of the magnetic field formed by passing a current through the wire is measured using a Hall effect device and converted to current distribution. The experiment was conducted under a self-magnetic field at 90 K due to the limitation of current source, and Fig. 3 a) shows the distribution of the self-magnetic field under critical current, Fig. 3 b) shows sheet-current distribution calculated from self-magnetic distribution, and Fig. 3 c) shows the distribution of critical-current density in the wire-width direction calculated from the sheet-current distribution and the distribution of cross-sectional area of superconducting filaments. A critical-current-density distribution having a peak of about 450 A/mm^2 at the center of wire was obtained. It is expected that the peak critical-current density is 900 A/cm^2 at 77.3 K, which is about twice the value at 90 K Assuming that the distribution of the critical-current density in the wire-width direction is uniform, the critical current is 340 A so that a critical current of 300 A is considered to be obtained even with the present different phase content and degree of orientation of Bi2223 phase.

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

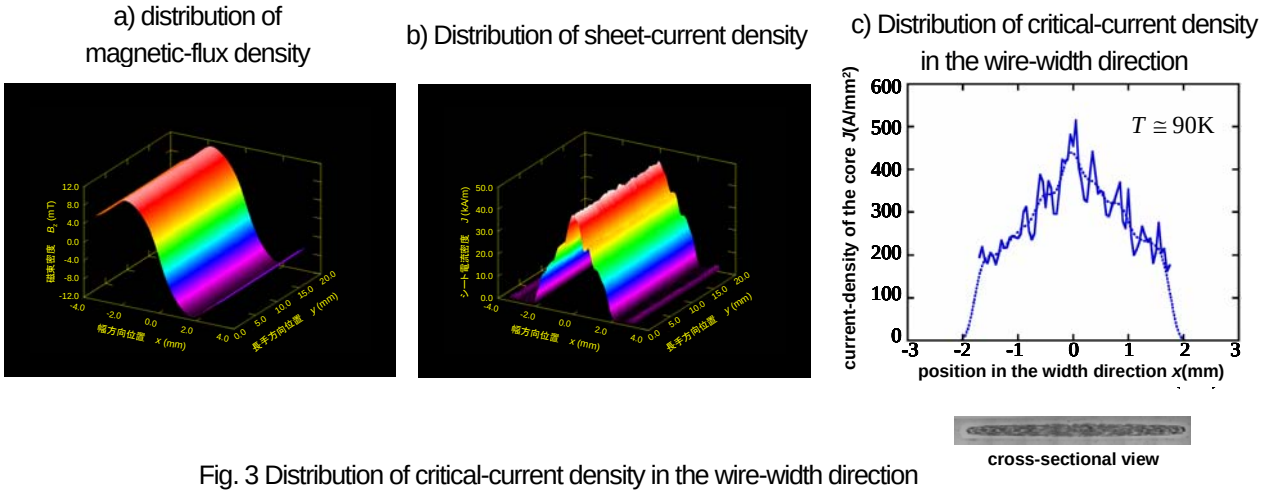

Fig. 3 Distribution of critical-current density in the wire-width direction

Reference:

1) Y. Honda, K. Higashikawa, M. Inoue, T. Kiss, N. Ayai, M. Kikuchi, K. Hayashi and K. Sato : "Study on current distribution in DI-BSCCO tape based on the scanning Hall probe magnetic microscopy", submitted to Physica C (proc. the ISS 2009)

(Published in a Japanese version in the April 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
超電導 Web21 Superconductivity
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Articles: Overview of superconducting-wire technology - Progress in MgB_2-wire processing technology -

Kazumasa Togano, Research Adviser
Superconducting Materials Center
National Institute for Materials Science

MgB_2 is considered to be promising for applications in a high-temperature range between 20 and 30 K, which can be obtained using a refrigerator since it has a critical temperature (T_c = 39 K) much higher than those of Nb-Ti and Nb_3Sn. Although nine years have passed since its discovery, the PIT (Powder-in-tube) method is still considered to be a major process because the process can produce long wires. In foreign countries, Columbus Superconductors (Italy) [1] and Hyper Tech Research Inc. (USA) are already producing practical wires of several km on commercial base and the products are applied to devices such as MRI. The greatest problem of PIT wires is how to improve magnetic characteristics and increase packing density. To solve the former problem, C substitution of B site is effective and many additives, including SiC, have been tried. However, further improvement is required for practical use. The other problem of PIT wires, i.e., the low packing density, is the essential problem of powder metallurgy. In case of MgB_2, the shrinkage during the reaction of $Mg+2B \rightarrow MgB_2$ makes it more difficult to solve the problem. Although high-pressure application is being tried to solve this problem [2], the development of a process based on a new concept seems to be necessary when production of long wires is taken into account.

From the viewpoint of getting high density, the diffusion method (for example: internal Mg diffusion (IMD) method [3] (Figure 1)), which is an improved PIT method is attracting attention. The feature of this method is to separate B layer and Mg layer and not mix the powders, and provoke the diffusion reaction. This method enables production of long wires, and a high critical-current density exceeding that of PIT wires is obtained due to the formation of a high-density MgB_2 layer. Figure 2 shows representative relationship between critical current density (J_c) and magnetic field (H). In addition to such an attempt of new technology, It is also important to continue the development of conventional PIT method to construct application systems as well as fundamental researches to essentially improve magnetic-field characteristics of MgB_2.

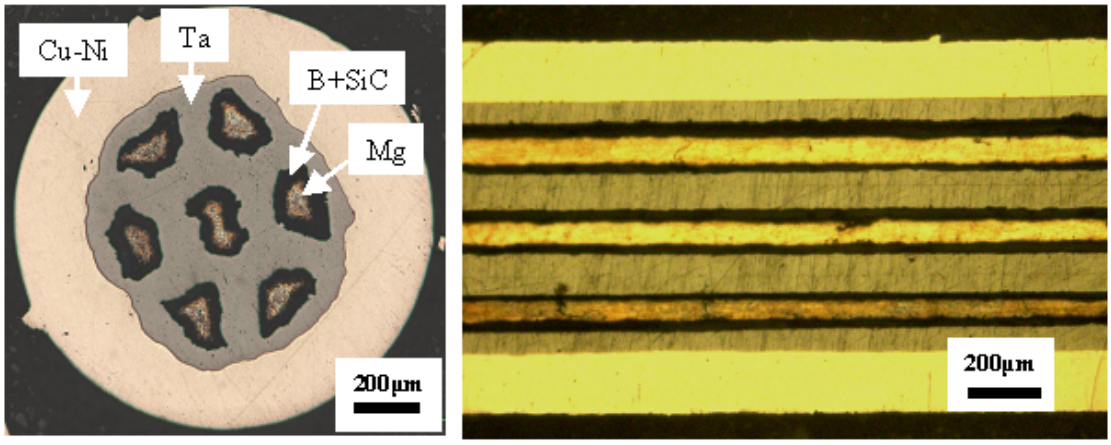

Fig. 1 Transverse section and longitudinal section of MgB_2 wire fabricated by internal Mg diffusion (IMD) method (before heat treatment) [3]

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

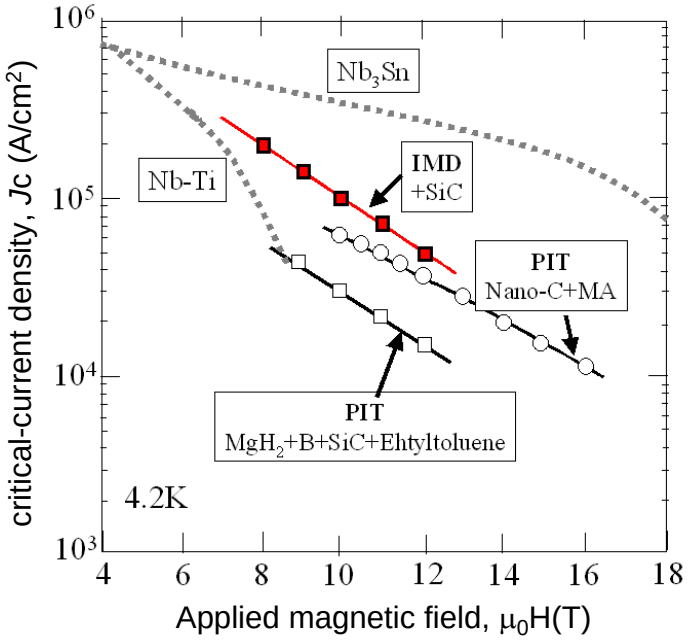

Fig. 2 Representative critical-current density (J_c)—magnetic field (H) curve of PIT wire[4),5)] and IMD wire[3)]. Curves of Nb-Ti and Nb_3Sn are shown for reference.

Reference:

1) G. Grasso *et al,* Abstracts of 22nd International Symposium on Superconductivity (ISS2009) (November 2009, Tsukuba Japan) p.119.
2) Yamada *et al*., Abstracts of CSJ Conference, 2009 Spring, (May 2009, Waseda University) p.193.
3) K..Togano *et al,* Supercond. Sci. Technol.22(2009)015003.
4) H. Yamada *et al,* Supercond. Sci. Technol. 20(2007) L30.
5) W. Heasler *et al,* Supercond. Sci. Technol. 21(2008) 062001.

(Published in a Japanese version in the April 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Feature Article: Overview of superconducting-wire technology - Trends in superconducting technology for nuclear fusion -

Nagato Yanagi
National Institute for Fusion Science (NIFS), National Institutes of Natural Sciences

This paper outlines the technical trends in superconductors for fusion magnets, and also introduces a discussion on the possibility of applying high-temperature superconductors (HTS) to future demo reactors and commercial reactors.

Early realization of nuclear fusion is hoped as a next-generation energy source of low environmental impact with abundant fuel on the earth. The International Thermonuclear Experimental Reactor (ITER) is now being constructed at Cadarache in France with international collaboration among seven parties — Japan, EU, USA, Russia, China, Korea and India, aiming to be operational in 2019. The expected maximum current, maximum magnetic field and stored magnetic energy of the superconducting magnet system of ITER are 68 kA, 13 T and 40 GJ, respectively, all of which significantly exceed those of existing systems. Cable-in-conduit (CIC) conductors, which are stable and have low AC losses, are used for winding conductors of all coils and cooled by supercritical helium supplied at 4.5 K. For the toroidal field (TF) coils (maximum field: 11.8 T) and central solenoid (CS) coils (13 T), Nb_3Sn wires are used. Japan is to produce 540 tons, about half of the total amount of wires. The production of wires (strands) is already in progress and the technology to stably produce wires has been established by satisfying the requirements of high-current density (> 720 A/mm^2 at 12 T and 4.2 K by bronze method and > 833 A/mm^2 by internal diffusion) and low hysteresis losses (<500 mJ/cc with a magnetic field change of ±3 T). Production of the final conductors through cabling and jacketing processes has also started. Since the maximum magnetic field of the poloidal field (PF) coils is in 6-T level, NbTi strands (about 250 tons) are to be used.

To intensively and rapidly develop fusion technology in parallel with the ITER project, the “Broader Approach (BA)” program has been initiated as a bilateral collaboration between Japan and EU. One of its projects, construction of the JT-60SA machine at Japan Atomic Energy Agency, has already begun. JT-60SA is a satellite tokamak of ITER with weight and magnetic energy one order of magnitude smaller than that of ITER so that flexible experiments are expected to begin in 2016. Initially, Nb_3Al wires were considered to be used for the TF coils. However, since the maximum magnetic field was lowered to 6-T level through optimization, NbTi wires are being used instead, as they are applied to the poloidal (equilibrium field; EF) coils. For these coils, NbTi wires of the LHC specification of CERN are used with 2 μm of Ni coating to reduce AC losses. The maximum magnetic field of the CS coils is ~9 T and Nb_3Sn wires of the ITER specification are used. Production of the CS and EF conductors has begun and sample conductors are being tested at NIFS using a 9 T split-coils facility.

Magnetic confinement configurations other than the tokamak are also being considered, among which the helical type is expected to make a stable reactor with high energy efficiency without the need for inducing plasma current. At NIFS, the Large Helical Device (LHD) project has been successfully conducted and a conceptual design of the helical-type fusion energy reactor FFHR is in progress. As it is a crucial mission to realize tokamak and/or helical demo reactors by the 2030s, superconductors with a capacity exceeding that of ITER are required. The basic idea for meeting this target is to use CIC conductors of Nb_3Sn or Nb_3Al wires as an extension of the ITER technology. However, in order to develop commercial reactors on a mass-production basis by the 2040s after the demo reactors, it is

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

useful to develop indirectly-cooled solid-type conductors so that the structures of the windings and cooling pipes of magnets may become less complicated. An example of the indirectly-cooled conductor uses Nb_3Sn or Nb_3Al wires within a jacket made of aluminum-alloy. Another advantage of this conductor is that the react-and-wind technique can be applied. One may also assume that a low-activation material, such as V_3Ga, is used in place of Nb-based materials.

In accordance with the rapid technological development in recent years, it has also become conceivable to apply high-temperature superconducting (HTS) conductors for fusion magnets. Using HTS conductors, it is expected that stable coils without a fear of quench may be realized with high energy efficiency due to the reduction of refrigeration power by elevated temperature operations. Typical conductor designs incorporating simple stacking of Y-based tape wires and/or Roebel-type conductors with transposition structures are being considered. One may also consider round wires of Bi-2212 or short-width Y-based tapes bundled and twisted to form CIC conductors. Although the production cost of HTS wires is presently a great issue, it is expected that significant cost reduction will be realized when wires are mass-produced for power applications in the near future. Under such circumstances, HTS conductors of large-size may be supplied even at a lower cost than that of the LTS counterparts (which are produced on an order basis). In addition, the extra cost of construction with HTS may be compensated by a reduction in the running cost of refrigerating power. Furthermore, when the operation temperature is high (60 K or higher, for example), there may be innovative changes that cannot be assumed with conventional LTS magnets, such as the elimination of 80-K radiation shields and/or application of solid insulators for supporting auxiliary coils from the vacuum-vessel. It is also possible in principle that gigantic coils are assembled with prefabricated segments; the segments would then be jointed on site. Joule heating in joints could be accepted at elevated temperature operations making use of a margin of refrigeration power. Gases other than helium, such as neon or hydrogen, could also be considered for refrigeration. In order to realize these innovative ideas, intensive research and development are required. At present, reduced-scale conductors of 10-kA class are being tested and remarkably high stability is being confirmed compared to that of LTS CIC conductors. While the present sample conductors include Y-based wires with critical currents of ~200 A/cm level (at 77 K, self-field), it is envisioned that the basic structure of the present conductor can be scaled up to the 100-kA class by applying the maximum available critical currents observed in the latest short wires (~1 kA/cm). Thus, it is anticipated that HTS large-current conductors can be used for fusion magnets when demo and commercial reactors will be built.

(Japanese version published in the April 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2010 Date of Issue: July 15, 2010
Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Standardization Activities

Topics in May

- JIS H 7305 “Critical-current measurement of Bi-based superconducting wires” and JIS H 7307: 2010 “Electronic characteristic measurements of superconductors” were published -

Masanao Mimura, Director,
Standardization Affairs Division, ISTEC

The Japanese Standards Association revised and published the following two JIS standards related to superconductivity on March 23, 2010 based on the deliberation of the Japanese Industrial Standards Committee.

♦ Title: Superconductivity - Critical current measurement - DC critical current of Ag- and/or Ag alloy-sheathed Bi-2212 and Bi-2223 oxide superconductors
Standard Number: JIS H 7305:2010
Date of enactment: March 23, 2010
Published by: Japanese Standards Association
Constitution of the standard: Introduction, Scope, Referenced standards, Terms and definitions, Principle, Test conditions, Equipment, Preparation of samples, Test procedure, Precision and accuracy of the test method, Calculation of test results, Items to be reported, Attachment A, Attachment B, Comments.
Outline of the revision: This standard is a revision of JIS H 7305:2003 and the major revision points are the following four items:

1) Addition of terms and definitions
2) Addition of principle
3) Revision of constant-speed sweeping and step sweeping
4) Revision of drawings

Preparation of standard draft: The draft was prepared by the JIS Draft Preparation WG3 (General Manager: Hitoshi Kitaguchi, Professor at the University of Tokyo) established under the JIS Draft Preparation Committee (Chairman: Kozo Osamura, Professor Emeritus at Kyoto University)
Corresponding international standard: IEC 61788-3:2006, Superconductivity - Part 3: critical current measurement - DC critical current of Ag-and/or Ag alloy-sheathed Bi-2212 and Bi-2223 oxide superconductors

♦ Title: Superconductivity - Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies
Standard Number: JIS H 7307:2010
Date of enactment: March 23, 2010
Published by: Japanese Standards Association
Constitution of the standard: Introduction, Scope, Referenced standards, Terms and definitions,

Superconductivity Web21
Published by International Superconductivity Technology Center
1-10-13, Shinonome, Koto-ku, Tokyo 135-0062, Japan Tel: +81-3-3536-7283, Fax: +81-3-3536-7318

Requirements, Equipment, Measuring procedure, Precision and accuracy, Test report, Attachment A, Comments.

Outline of the revision: This standard is a revision of JIS H 7307:2005 and major revision points are the following five items:

1) Transfer of the item of principle to Attachment.
2) Adoption of closed measuring jig.
3) Expansion of the scope of application of the sapphire cylinder.
4) Revision of the procedure to determine surface resistance.
5) Total revision of the mode charts of Attachment.

Preparation of standard draft: The draft was prepared by the JIS Draft Preparation WG8 (General Manager: Shin Kosaka, Affiliate Researcher at National Institute of Advanced Industrial Science and Technology) established under the JIS Draft Preparation Committee (Chairman: Kozo Osamura, Professor Emeritus at Kyoto University)

Corresponding international standard: IEC 61788-7:2006, Superconductivity - Part 7: Electronic characteristic measurements - Surface resistance of superconductors at microwave frequencies

Please order JIS Standards directly from the web store of Japanese Standards Association (http://www.jsa.or.jp; 107-8440, 4-1-24 Akasaka, Minato-ku, Tokyo; TEL: 03-3538-8002; FAX: 03-3583-0462)

(Published in a Japanese version in the May 2010 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21