超電導 Web21
Superconductivity

Summer, 2005 Date of Issue: July 15, 2005

# Superconductivity Web21

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## What's New in the World of Superconductivity (May)

### Power

**SuperPower, Inc. (May 19, 2005)**

SuperPower Inc., a subsidiary of Intermagnetics General Corporation, has announced the launch of a collaborative training program with the Schenectady County Community College and Union College, both located in Schenectady, NY. The training program will help to develop the highly skilled technical workforce that SuperPower requires to produce second-generation HTS wire. The collaboration partners have been awarded US $5 million of the 2006 New York State Legislative Budget to purchase capital equipment and to complete the facility upgrades needed for the program. Glenn H. Epstein, chairman and chief executive officer of Intermagnetics commented, "This unique and innovative program will provide practical experience and training for locally based students in engineering and technology who we envision will augment the highly skilled workforce required at SuperPower and other related high tech industries in the Capital Region."

Source:
"Intermagnetics Subsidiary Announces Launch of $5M New York State Funded Training Program"
SuperPower Inc. press release (May 19, 2005)
http://www.igc.com/news_events/news_story.asp?id=158

**Trithor GmbH and Bültmann GmbH (May 31, 2005)**

Trithor GmbH and Bültmann GmbH have announced that they will jointly make a new cost-effective and resource-saving induction heater to be installed and tested in 2007 at the manufacturing site of Mendener Präzisionsrohr GmbH in a project supported by the Deutsche Bundesstiftung Umwelt (DBU, German Federal Environment Foundation). The new induction heater will have a thermal rating of 1 MW. The use of HTS superconductors will enable the heater's coefficient of performance to be increased from about 50% (the value for conventional induction heaters) to 90% for the heating of metals like copper or aluminum, thereby cutting running costs in half. Dirk Schötz of the DBU commented, "This is an excellent example of an innovative technology where cost savings for industrial users and environmental compliance go hand-in-hand."

Source:
"First Industrial Installation of HTS Induction Heater"
Trithor GmbH Press release (May 31, 2005)
http://www.trithor.de/pdf/2005-05TrithorInductionHeaterAppl_en.pdf

### Communication

**Superconductor Technologies Inc. (May 5, 2005)**

Superconductor Technologies Inc. (STI) has reported its financial results for the first quarter ending April 2, 2005. Total net revenues for the first quarter decreased to US $4.4 million from $5.4 million for the same quarter in the previous fiscal year. Net commercial product revenues, on the other hand, increased by

  

18% to $3.8 million from $3.2 million for the same quarter in the previous fiscal year. Government and other contract revenue amounted to $571,000, compared to $2.2 million for the same period in the previous fiscal year. Net loss for the first quarter was $5.5 million, including special charges of approximately $700,000 in connection with restructuring and the former chief executive officer's retirement. Jeff Quiram, STI's president and chief executive officer, commented, "As of April 2nd, we had commercial product backlog of $5.1 million, compared to $730,000 at the end of 2004. In addition, we have a purchase agreement with another customer under which a minimum of $5.3 million in commercial product is expected to be delivered by the end of 2005."
Source:
"Superconductor Technologies Inc. Announces First Quarter 2005 Results"
Superconductor Technologies Inc. (May 5, 2005)
http://phx.corporate-ir.net/staging/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=706375&highlight

**ISCO International, Inc. (May 18, 2005)**

ISCO International, Inc., has provided a mid-quarter update on their business activity in the second quarter. Orders that have been delivered or are scheduled for delivery in the second quarter are now in excess of US $2 million. This figure is expected to grow as the quarter progresses. New product development is also progressing well, with new products expected during each quarter of 2005.
Source:
"ISCO International Updates Second Quarter Activity"
ISCO International, Inc. press release (May 18, 2005)
http://www.iscointl.com/

**Superconductor Technologies Inc. (May 24, 2005)**

Superconductor Technologies Inc. (STI) has received approximately US $4 million dollars (year to date) in orders for SuperPlex® and AmpLink™ products as part of a major wireless carrier's 3G (EV-DO) rollout. SuperPlex enables antenna and cable sharing without degrading the performance of underlying cellular networks, providing a cost-effective way to simplify the installation of personal communication services (PCS) signals over existing 850 megahertz (MHz) cellular networks. STI's SuperPlex product line also includes a line of 850 MHz and 1900 MHz duplexers with industry-leading insertion loss and band rejection performance. The AmpLink solution, available in both an outdoor and a compact indoor configuration, provides duplexing and uplink enhancement for PCS base stations. Together, the products have been used in rollouts of 3G data networks to improve the link quality in both forward and reverse directions, maximizing the performance of the new networks while maintaining the cell spacing of existing 850 MHz networks. STI began shipping the products in March and will continue to do so through the second quarter of 2005. The financial terms of the orders were not disclosed.
Source:
"Superconductor Technologies Receives Orders for Products Used in 3G Data Overlay"
Superconductor Technologies Inc. (May 24, 2005)
http://phx.corporate-ir.net/staging/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=712974&highlight

(Akihiko Tsutai, Director, International Affairs Department, ISTEC)

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# Feature Articles : Superconducting Microwave Device Technology - Expectations of Superconducting Devices for High Frequency Applications -

## 1. Preface

There are many types of superconducting devices. They can be classified into analog and digital applications and sometimes into active and passive devices. Superconducting devices can be viewed from different perspectives depending on the category that they are classified under. These feature articles focus on application frequencies.

SQUIDs (superconducting quantum interference devices) for measuring extremely small magnetic fields such as heart and brain magnetic fields handle relatively low frequencies from 1 Hz to about 1 kHz. Many other superconducting devices handle high frequencies ranging from very high frequency devices, to ultra high frequency, microwave, millimeter wave, sub-millimeter wave and far infrared devices. In the frequency regions from several hundred MHz to several GHz bands, the development of superconducting filters, AD converters and other devices is underway and the Superconductivity Web21 has often taken them up as development goals.

Additionally, a variety of applications are considered widely in these frequency regions. Humans can see objects only in visible ray region from red to violet. By seeing objects, sending and receiving information and transmitting energy on waves in other frequency regions, human lifestyles will be widely extended. Aside from making life more convenient, this will greatly contribute to the welfare of mankind such as solving energy and environmental problems and assuring peace of mind. Superconductivity technology plays an important role in providing such means. This series of articles takes up microwave application of superconducting devices and applications of a slightly wider frequency ranges. The current status of superconducting filters for broadcasting and a large-power gyrotron that uses superconducting magnets, as well as applications of terahertz waves, is overviewed, supplemented by commentaries by experts in these fields that follow this introductory article.

## 2. Application of Superconducting Devices to High Frequencies

Plotting frequency bands on the axis of abscissas, Fig. 1 shows specific examples in various application fields. Radio waves that closely interact with our everyday life are flying in wide frequency bands from very high frequency waves to sub-millimeter waves. The services in the very high frequency region include VHF TV broadcasting, while the services in the ultra high frequency region include UHF TV broadcasting, cellular phones and taxi wireless service. The services in the microwave region include satellite broadcasting and microwave relay radio waves, while the services in the millimeter wave region include radio astronomy and environmental diagnosis through the observation of radio waves emitted by ozone molecules in the upper atmosphere. Applications in the sub-millimeter region are often called terahertz wave applications, and applications in many fields are expected such as the detection of drugs contained in envelopes.

Superconducting devices are in some way related to such wide frequency regions, indicating how wide the superconductivity technologies are. These technologies can be grouped into several categories.

(1) Superconducting antennas for collecting signal radio waves
(2) Superconducting sensors for receiving very feeble radio waves
(3) Superconducting filters for selecting signal frequencies
(4) Superconducting AD conversion circuits for converting received analog signals into digital signals
(5) SFQ (single flux quantum) logic circuits for ultra high speed processing of digital signals
(6) Generation of sub-millimeter waves by superconducting thin films or Josephson devices
(7) High speed waveform measuring circuits (superconducting sampler)

  

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(8) Application of superconductivity technologies to apparatuses and systems for supplying energy as electromagnetic waves

Filters and sensors have already been commercialized in cellular phone base stations and environmental measurement in the United States. Research and development of many types of devices is underway.

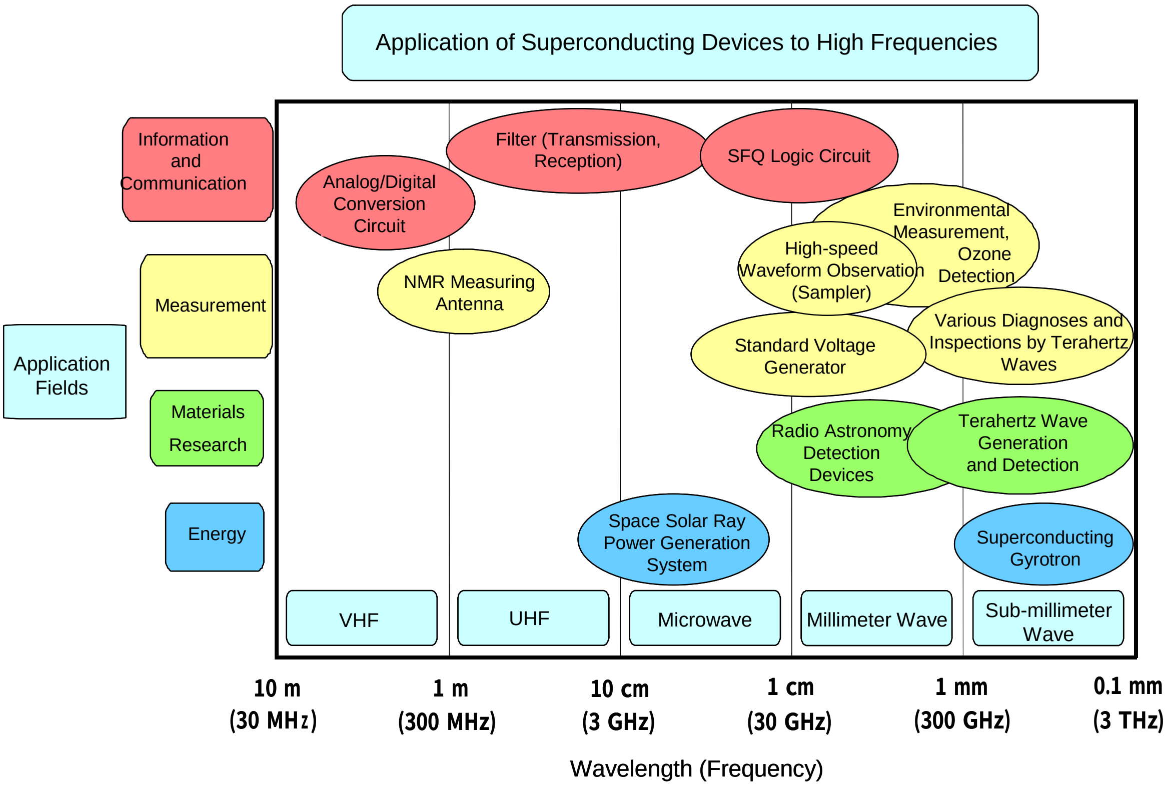


Fig. 1 Examples of Applications of Superconducting Devices to High Frequencies

## 3. Future View

These superconducting devices are rarely commercially available to ordinary citizens. However, these devices are expected to be used in various fields in the future. Needless to say, new technologies grow when they are actually used. However, only some of these devices have been used and many of them are still new or potential technologies. How they are applied in the future depends much on the fostering power of protectors called technology development and on educational organizations called opinions of users in the field. Researchers engaged in research and development must perfect products or prototypes viable in practical use as early as possible and the users must present strict requests incorporating expectations. As a result, these devices will grow steadfastly with the market size expanding, prompting expectations for a next generation of superconducting devices.

(Shinya Hasuo, Director, SRL/ISTEC)

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# Feature Articles : Superconducting Microwave Device Technology - Development of Superconducting Filter for Digital Terrestrial Broadcasting -

Tatsunori Hashimoto
Advanced Functional Materials Laboratory, Corporate Research & Development Center
Toshiba Corporation

Hisao Nakakita
Fukuoka Station
NHK (Japan Broadcasting Corporation)

In December 2003, digital-terrestrial-television broadcasting was started in three megalopolises in Japan, namely, Tokyo, Osaka and Nagoya, and their respective service areas are currently being expanded. Relay stations for digital-terrestrial-television broadcasting to receive broadcast waves that have become weak and to amplify and transmit them to viewers' homes in more distant areas will be installed along the edges of service areas throughout Japan.

In these relay stations, transmitting waves couple to the receiving antenna as disturbing waves when transmitting and receiving channels are adjacent to each other at the same transmission site, causing serious interference. (Fig. 1) This is caused by a gentle characteristic of the receiving filter installed in the relay station, and also by waves passing adjacent to the receiving channel. (Blue curve in Fig. 2) This interference can be drastically reduced by using a superconducting sharp-skirt filter as a receiving filter. (Red curve in Fig. 2)

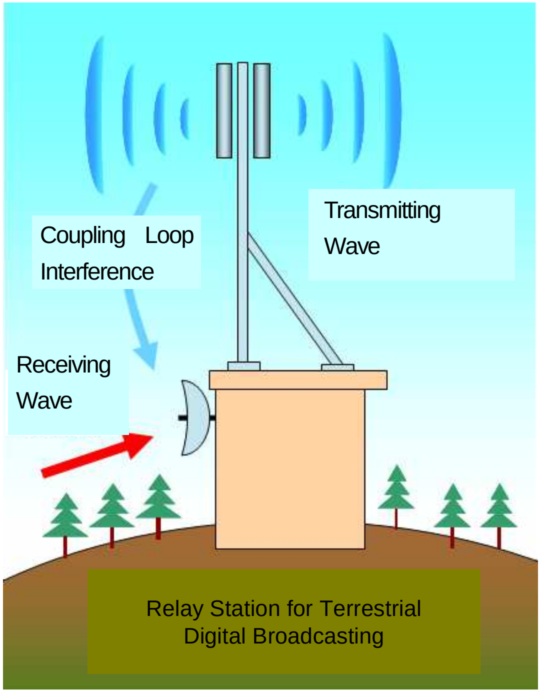


Fig. 1 Coupling Loop Interference of Adjacent-channel Transmitting Wave

A full view of the superconducting filter unit jointly developed by NHK (Japan Broadcasting Corporation) and Toshiba Corp. is shown in Fig. 3. This prototype unit can be installed in a rack and superconducting filters for up to four channels can be packaged per unit. A long-life compact cryocooler developed for cellular phone base stations is embedded in the prototype for cooling the filters, assuring continuous operation only by supplying the power.

A laboratory experiment of the prototype has verified that this unit significantly improves the reception performance when the undesired coupling loop interference wave is stronger than the desired receiving wave's signal. The study will be continued in order to commercialize this filter unit.

## References

1) Hisao Nakakita, Kyoko Kanamori, Tatsunori Hashimoto, Hiroyuki Fuke, Hiroyuki Kayano, Fumihiko Aiga, Yoshiaki Terashima and Mutsuki Yamazaki, 2004 NAB BEC Proceedings, pp. 137-140 (2004)

  

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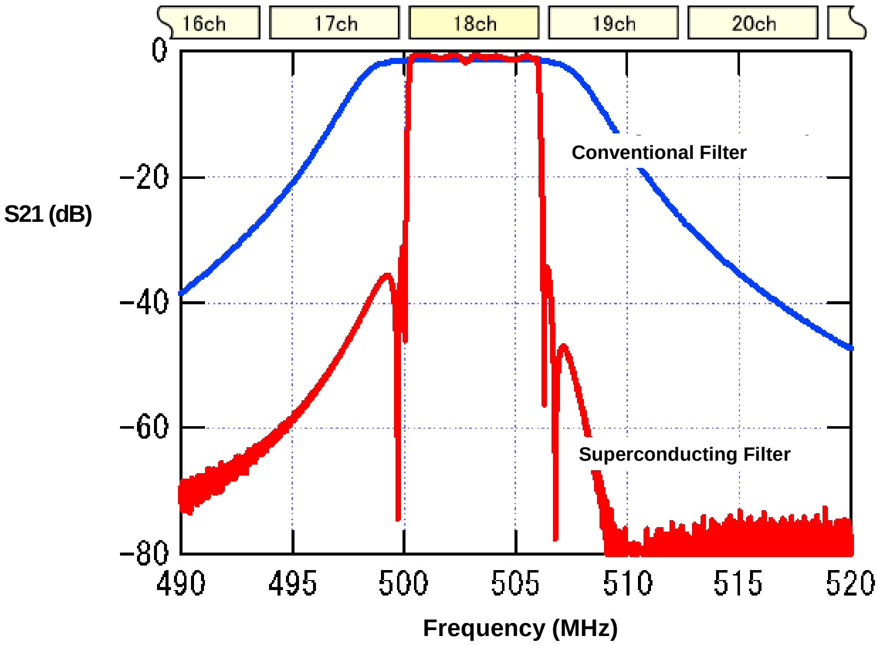


Fig. 2 Example of Frequency Response of 12-pole Quasi-elliptic Superconducting Filter for Digital-terrestrial-television Broadcasting Channel 18
The filter substrate size is 50 mm x 50 mm.


Fig. 3 Photo of Superconducting Filter Unit

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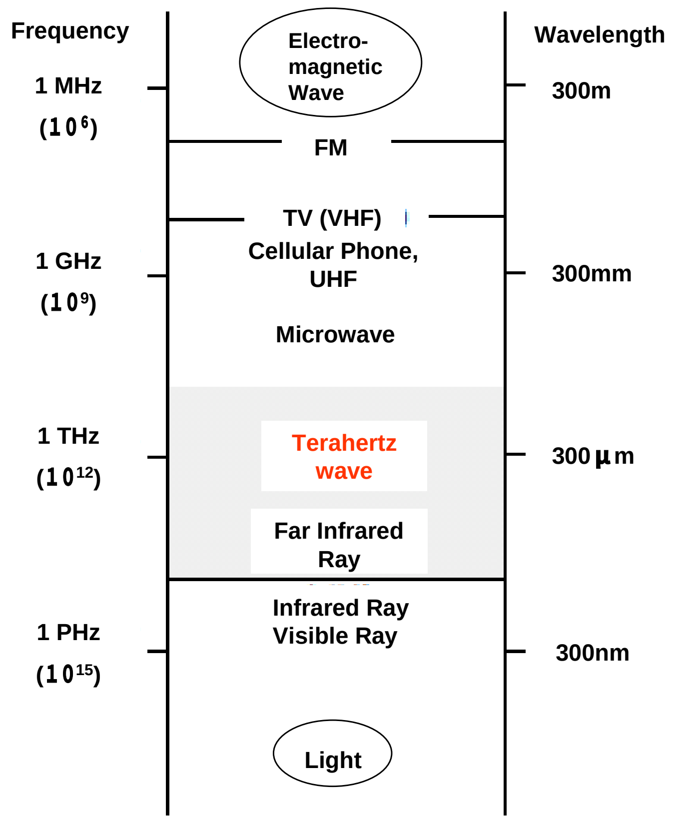
## Feature Articles : Superconducting Microwave Device Technology - Expectations of Terahertz Wave Light Sources -

Shinichi Uchida, Professor
Department of Physics, Graduate School of Science
The University of Tokyo

In early 2005, the Science and Technology Council unveiled ten key technologies as development targets for Japan in the next ten years. The first key technology is “measuring and analytical techniques by terahertz waves,” aimed at “diagnosing histopathology and discrimination of drugs and explosives in mail utilizing the permeability of terahertz waves.”

Terahertz waves are electromagnetic waves at frequencies of $10^{11}$ to $10^{13}$ called “electromagnetic waves of an undeveloped region.” Terahertz waves are frequencies that are higher than microwaves and are lower than infrared rays, including the frequency regions called sub-millimeter waves and far infrared rays. These regions are called “undeveloped” because there have been no light sources that provide sufficient intensities and frequency bands needed to evolve as science and technology.

Terahertz waves have unique characteristics that are not found with electromagnetic waves of other frequency bands. Several characteristics of terahertz waves that are considered important in applications are as follows. (1) High penetration into plastics, vinyl, paper, rubber, wood and other materials that contain no or only negligible amounts of water. Low possibilities of damaging articles and radiation exposure to human bodies. For these reasons, terahertz waves are expected to be applied as rays for nondestructive safety examinations replacing X-rays. (2) Water and water vapor are extensively absorbed by terahertz waves so that terahertz waves cannot propagate in the air and cannot permeate human bodies. However, terahertz waves can be high-sensitivity sensors of $H_2O$. (3) Metals strongly reflect terahertz waves and are opaque to terahertz waves. However, metals can be used as waveguides and light condensers (concave mirrors). (4) Frequencies of molecular and lattice vibration and of plasma vibration of minor carriers in semiconductors are in the terahertz band. Superconducting gap energy and heat energy of a normal temperature involved in the function manifestation of bio materials also correspond to photon energy of the terahertz region.



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In the past decade, expectations of terahertz waves that have these characteristics have surged and technology development of terahertz waves has become active. Excellent light sources of terahertz waves are being developed and new terahertz wave spectroscopy using laser and semiconductor technologies are spreading. The light sources that have been developed recently are compact, high output light sources. They are diverse in nature. These light sources generate terahertz waves using nonlinear optical crystals and semiconductor GaAs, radiative terahertz emission from Ge hot carriers of the p type and use the intrinsic Josephson junction in high-temperature superconductors. Commercialized light sources for terahertz waves are expected to be developed before 2009.

The new spectroscopy using terahertz waves is called "terahertz time domain spectroscopy." Using an ultra short pulse laser of femtoseconds ($10^{-15}$s), terahertz waves are generated and detection is made simultaneously. The most prominent feature of this technique is the high time resolution, allowing high-speed phenomena to be captured in the terahertz region. It will not be too long before "terahertz imaging" using this technique is actively used in analyzing functions of bio materials, internal examinations of ICs, histopathological diagnosis and other purposes.

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# Feature Articles : Superconducting Microwave Device Technology - Development and Application of High Power Sub-millimeter Wave Radiation Source (Gyrotron) -

Toshitaka Idehara, Professor
Director, Research Center for Development of Far Intrared Region
University of Fukui

"Gyrotron" is a radiation source for millimeter waves and sub-millimeter waves based on an oscillation principle of "cyclotron resonance maser" that uses mass changes of electrons by a relativistic effect. The gyrotron has the following features: 1) High efficiency operation exceeding 50% in beam efficiency. 2) High power operation by injecting electron beams of high energy and large current. 3) Tunable wavelength by changing the setting of the cyclotron frequency.

The sub-millimeter wave region is the only one electromagnetic wave region whose development is lagging behind due to lack of a radiation source that operate stably with high power in this wavelength region and high sensitivity receiver. For this reason, the sub-millimeter wave region is called a "gap of electromagnetic waves." The gyrotron as a radiation source of high-power sub-millimeter waves can be developed by performing high-order cyclotron harmonic operation in a high magnetic field. As a result, a radiation source that stably operates with high power in the sub-millimeter wave region can be implemented.

The Research Center for Development of Far Intrared Region, University of Fukui has conducted research on cyclotron harmonic operation in five successive orders and a high frequency gyrotron using a superconducting magnet with a maximum magnetic field intensity of 17T. A radiation source that is 890 GHz (wavelength 337 μm) at a maximum frequency and 100 W class in output power has already been developed. Similar research is also being conducted at MIT (USA), IAP (Russia) and University of Sydney (Australia). The maximum frequency of 890 GHz is the record frequency at present. A sketch of a gyrotron that uses a 17T superconducting magnet is shown in Fig. 1.

The gyrotron has accomplished modulation and high stability of output frequency and amplitude and meets the specification as a radiation source in the sub-millimeter wave region. The gyrotron has been used as a radiation source for plasma scattering measurement, materials science (sub-millimeter wave ESR research) and new medical technology development. High expectations are placed on the gyrotron as a key technology to realize new dream technologies in the future by providing a radiation source for developing high power technologies in the sub-millimeter wave region (or terahertz band and far infrared region).

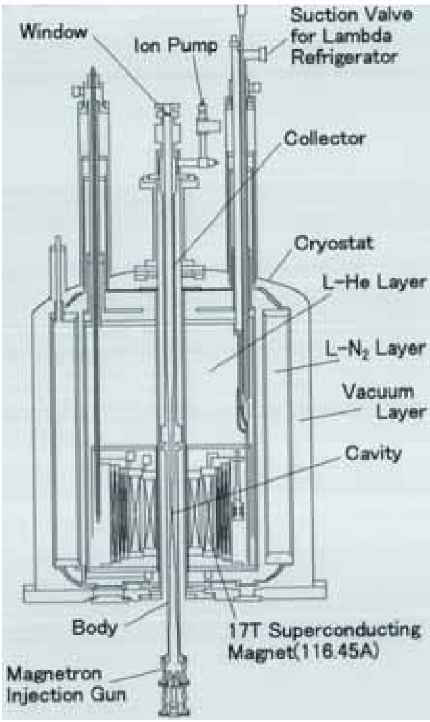


Fig. 1 Typical high frequency gyrotron (Gyrotron FU IVA)

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# Feature Articles : Superconducting Microwave Device Technology - Current Status of Surface Resistance Measurement of Thin Films and Standardization of It -

Shin Kosaka, Deputy Director
Evaluation Department
National Institute of Advanced Industrial Science and Technology

The excellent low loss characteristic of superconducting microwave devices is derived from extremely low surface resistance of superconducting thin films. IEC/TC90/WG8 initiated activities to standardize measurement methods for surface resistance, because surface resistance is a key parameter that controls device characteristics. In January 2002, IEC 61788-7 Superconductivity - Part 7: Electronic characteristic measurements - Surface resistance of superconductor at microwave frequencies was issued as a standard (IS) for surface resistance measurement methods. The surface resistances of superconducting thin films are about 0.1 mΩ or less at 10 GHz and 70 K. As a technique to accurately measure these small values with an uncertainty not to exceed 20%, IS uses the two-resonator method.

This IS has just been issued, however, the establishment of better measurement methods that can be used easily by more organizations (measurement methods that do not require sophisticated measuring know-how) is desired. At the IEC/TC90 meeting held in Argonne, USA, in September 2004, the IS maintenance policy was discussed. It was agreed to issue a maintenance document before 2009 and studies of the following topics were started.

1) Expansion of standard measuring frequencies

The IS currently sets 12 GHz as a standard measuring frequency and 18 GHz and 22 GHz will be added as new measuring frequencies. High measuring frequencies allow measurement of thin films of small sizes. Furthermore, surface resistances of superconductors increase in proportion to the square of the frequency and surface resistance can be measured easily.

2) Recommendation for closed type resonator

The two-resonator method calculates the surface resistance of superconductors by measuring unloaded Q values in two modes, TE011 and TE013. If an electromagnetic field of a mode to leak an electromagnetic field (parasitic mode) is excited outside the resonators, the Q value is lowered, causing large measurement errors. As the structure of resonators to suppress excitation of the parasitic mode, a closed type resonator structure, which places a copper cylinder around the dielectric resonators is recommended.

3) Dielectric anisotropy of sapphire is considered

The diameter and heights of sapphire rods constituting dielectric resonators must be carefully selected so that two TE011 and TE013 modes do not couple to other TM, HE and EH modes. The diameter and heights of a sapphire rods comprising dielectric resonators will be reviewed based on the most recent calculations that take the dielectric anisotropy of sapphire into consideration. This review is expected to enhance measurement reproducibility.

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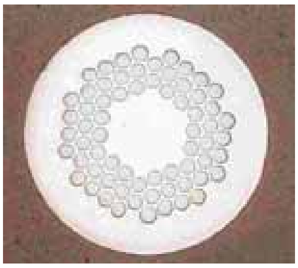
# Feature Articles : Superconducting Wire Technology
# - Wire Leads Future of Superconductivity Applications, For Technology that will be Used -

In this issue, research and development engineers working at the frontline introduce state-of-the-art superconducting wires. In the business field, the past decade in Japan has been a blank decade of economic recession and restructuring. In spite of such situation, however, superconductivity technology, especially wire technology, has progressed significantly .since 1995: 1) Bi wires are now produced in large quantities and various system applications have been studied. 2) Fujikura, IGC (USA) and SRL have developed Y wires of the 100 m class. 3) New material of $MgB_2$ has been found and development of $MgB_2$ wire has advanced rapidly.

The photos show cross sections of (a) NbTi wire and (b) $Nb_3Sn$ wire that have been commercialized, as well as (c) Bi-2212 wire and (d) Bi-2223 wire studied for application equipment using wires in lengths of 1 km order. Although researchers have made strenuous efforts to achieve the commercialization of these wires over the past two or three decades, many idea and research has not been realized. We imagine the difficulty of developing viable technology. Few research results lead to successful technologies, showing how challenging the development of high technology has become.

The researchers who have contributed their papers to this feature article have developed useful technologies under these circumstances. These important wire technologies will undoubtedly survive in the future. When $Nb_3Sn$ made a debut after NbTi, a high magnetic field coil became a reality. Bi wire has realized liquid nitrogen cooled AC cable system for the first time. Recalling development activities over many years, wire technology has always led innovation in superconductivity. The wires mentioned above will still need a technological reform. The final wire shape and other parameters of the Y wire that we are now developing will be decided in the future according to the requirements in applications. (This is



(a) NbTi

(b) $Nb_3Sn$

(c) Bi2212


(d) Bi2223

Photos a) NbTi multi-filamentary wire (bright areas are Cu, dark areas are NbTi filaments). b) $Nb_3Sn$ multi core wire (bright areas Cu, dark areas $Nb_3Sns$). c) Bi-2212 multi-filamentary wire (bright areas Ag, dark areas Bi-2212). d) Bi-2223 multi filamentary wire (bright areas Ag, dark areas Bi-2223). All round wires are several μm to several ten μm in filament diameter and about 1mm in outside wire diameter.

the reason why a cross section photo of the Y wire is not shown) The technologies to be used have not been decided yet and there is fierce competition. It is hoped that the feature article in this issue will stimulate further technology development and researchers that will motivate further advances.

(Yutaka Yamada, Director, Nagoya Coated Conductor Center, SRL/ISTEC)

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# Feature Articles : Superconducting Wire Technology
## - Technology Advances of 100 m-class Y Wire -

Yasuhiro Iijima
Superconductor Group, Metallic Materials Department
Material Technology Lab.
Fujikura Ltd.

Y superconducting ($YBa_2Cu_3O_{7-x}$ (YBCO)) wire is being developed because it demonstrates high characteristics in a high temperature region near the liquid nitrogen temperature and in a high magnetic field and promises applications under the widest operating conditions among the existing superconducting materials. From the standpoint of avoiding grain boundary weak bonding, the tape has to be a thin-film tape wire that is highly oriented and the process is being developed in parallel employing different methods. These methods have both advantages and disadvantages. Generally, metal substrates that can be used with methods that allow high-speed synthesis and low cost are limited, and high characteristics cannot be obtained easily with these methods.

The ion-Beam-Assisted Deposition (IBAD) method proposed by Japan in the earliest stage fabricates high quality intermediate-layer thin films of a single crystal-like structure on a non-magnetic and high strength orientation-free alloy tape. This method fabricates thin films of high characteristics and is easy to handle. For these reasons, the development of this method is most advanced. Thanks to the recent advances in large ion source technology, high-orientation $Gd_2Zr_2O_7$ intermediate layer films of the 250 m class can be stably fabricated. Additionally, new methods have been developed such as improving the orientation property through self selective growth by the PLD method on intermediate layer films of small particle size fabricated by the IBAD method. At present, an IBAD apparatus to deposit an orientational intermediate layer 500 m in length at a target speed of 5 m/h is being built.

The development of film deposition technologies for wires using the PLD method has been undertaken from early on for deposition of YBCO thin films. In 2004, Fujikura achieved characteristics of Ic = 126 A and Jc = 1.3 A/cm$^2$ on the entire length of 105 m, achieving 13230 Am, which is more than $10^4$ as a product of Ic and length, and verifying stable operation for a solenoid winding coil by wire of the same class in liquid nitrogen cooling for the first time. (Fig. 1) The development of a large-area film deposition technology to achieve both a higher throughput and lower dispersions is underway at present using laser beam scanning, multi-turn substrate tape transfer, radiation heating film deposition mechanism and other techniques. Figure 2 plots champion values of the characteristics of Y wires reported in the past relative to wire lengths. In America, an Ic value of 1000 A per cm has been recorded with short samples in a study of a multi layer structure. Advances have been reported with other YBCO film deposition methods, such as the CVD method and thermal evaporation method, as well as with the non-vacuum process (MOD method) developed by AMSC and other

Fig. 1 Solenoid coil fabricated using Y wire

  

organizations. In the future, enhancement of pinning characteristics and evaluation of stability and losses will become important as wires available on the market, as well as the development of production engineering techniques with a focus on high volume production and cost reduction. It is now time to study prototyping and the evaluation of magnets and other products targeting commercial applications.

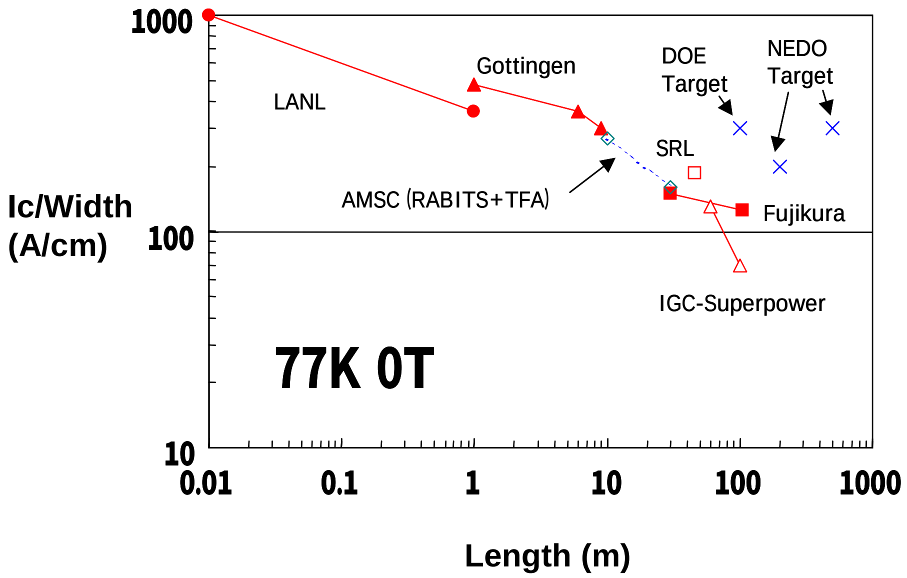


Fig.2 Champion value of Ic characteristic to each length of Y wire

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# Feature Articles : Superconducting Wire Technology
## - Spreading of High-performance Bi-2223 Wire -

Kazuhiko Hayashi
HTS R&D Department
Sumitomo Electric Industries, Ltd.

Superconductivity-applied equipment requires a high current density, long length and homogeneity performance of superconducting wires. The most advanced wire that has been developed in this respect is (Bi, Pb)$_2$Sr$_2$Ca$_2$Cu$_3$O$_y$ (Bi-2223) high-temperature superconducting wire.

The Bi-2223 superconducting wire is manufactured by a method called the PIT (Powder In Tube) method, which is a tape shape of 4.1 to 4.5 mm in width and 0.20 to 0.24 mm in thickness. (See Fig. 1) The superconducting filaments, which are made of a ceramic material, are covered with silver or a silver alloy, constituting a multi-core structure to provide flexibility.

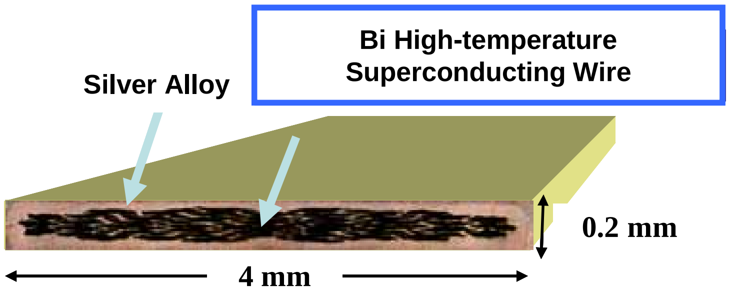


Fig. 1 Schematic depiction of cross section of Bi-2223 wire with multi-core structure

In obtaining a high Jc wire, it is important to prohibit the generation of cracks to the extent that cracks can be recovered by sintering in the rolling process, to make the filament density as high as possible and to sinter without lowering the filament density. In the secondary sintering process, an over pressure sintering method was used to repair cracks formed during rolling and to simultaneously solve the problem of low density during sintering.

Photo 1 shows SEM photos of filament microstructure of a conventional atmospheric-pressure sintered wire and pressurized sintered wire. The relative densities of the filaments were about 85% for the conventional atmospheric-pressure sintered wire and roughly 100% for the pressurized sintered wire.

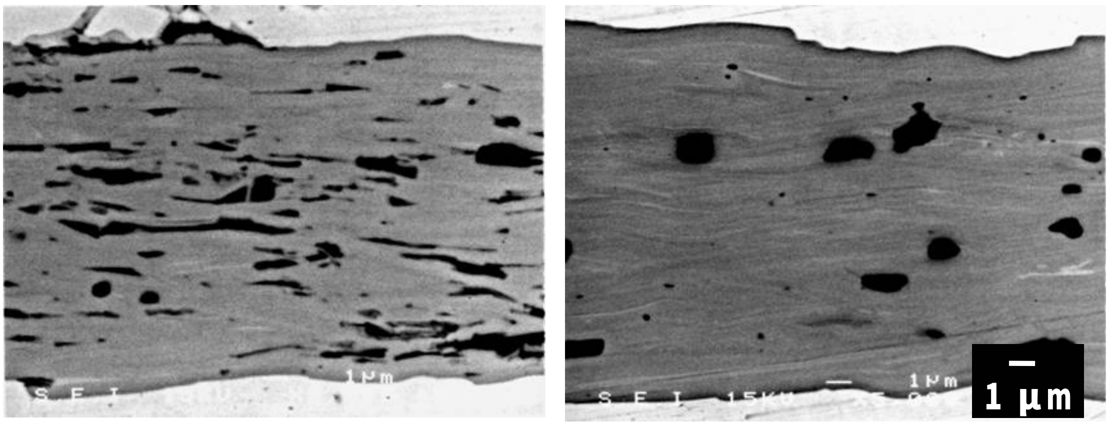


Photo 1 SEM images of filament after sintering
(Left: Atmospheric-pressure sintered wire Right: Pressurized sintering)

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The critical current (77 K, 0 T) were 99 A for the conventional atmospheric-pressure sintered wire and 130 A for the pressurized sintered wire, up about 30%. Pressurized sintering homogenized the filament texture, allowing fabrication of long-length wires at a high yield. Recently, as shown in Fig. 2, wires of a 1500 m class can be manufactured and the manufacture of longer lengths is being studied. As shown in Fig. 4, mechanical characteristics have been improved more than 70% compared with conventional wires. At 77 K, the tensile strength was about 200 MPa and is useful for application as magnets. The critical tensile strength of a high strength type (silver ratio 2.2) was about 300 MPa. The application range of magnets that can be fabricated without reinforcement such as stainless steel has been expanded. The ballooning phenomenon, which is a problem with the conventional atmospheric-pressure sintering when wires and transformers are used in liquid nitrogen, is perfectly prevented by increasing the filament density to 100% by pressurized sintering, to perfectly prevent entry of liquid nitrogen to the inside of the filament. (Fig. 3) The reliability of cables and other parts used in liquid nitrogen is greatly improved.

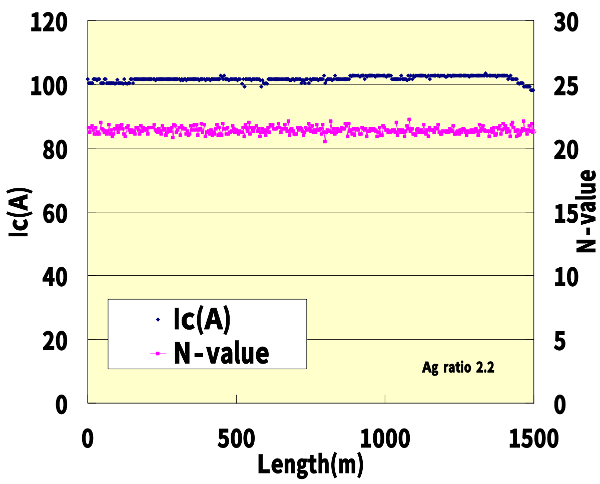


Fig. 2 Example of characteristic of 1500m wire

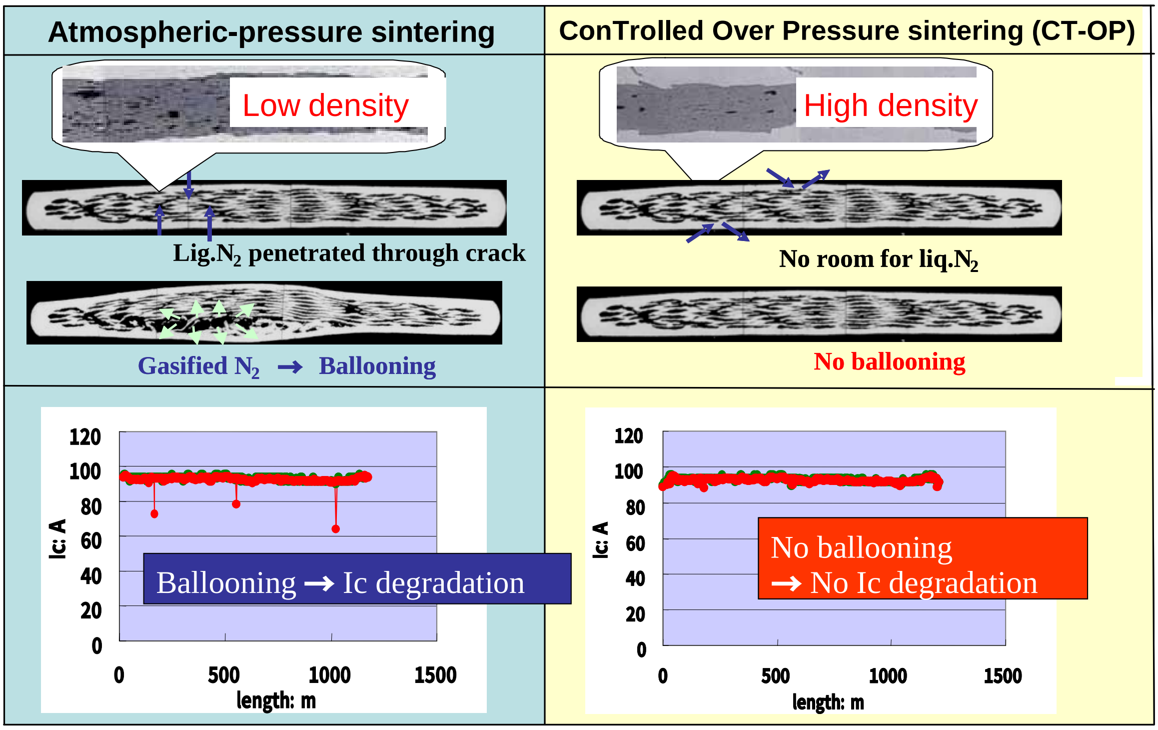


Fig. 3 Curbing of ballooning by pressurized sintering

  

These performances intrinsically differ from those of BSCCO wires and these wires are considered revolutionary wires that can be considered second-generation BSCCO wires. (Sumitomo Electric calls these wires "DI-BSCCO (Drastically Innovative BSCCO).

The pressurized sintering method allows the manufacture of high-performance long wires with a high yield and these wires have been supplied for use in cables (Albany project of USA and KEPRI project of Korea). These wires have been successfully used in the development of the world's first superconducting motor cooled by liquid nitrogen.

Superconducting wires create values only when they are used as equipment. The development of peripheral element technologies is mandatory as equipment, such as cooling and insulation, aside from the manufacture of wires. Sumitomo Electric will pursue its mission as a wire and cable manufacturer so that DI-BSCCO will contribute to the future development of equipment and systems and the high-temperature superconductivity technology will be recognized soon as viable technology.

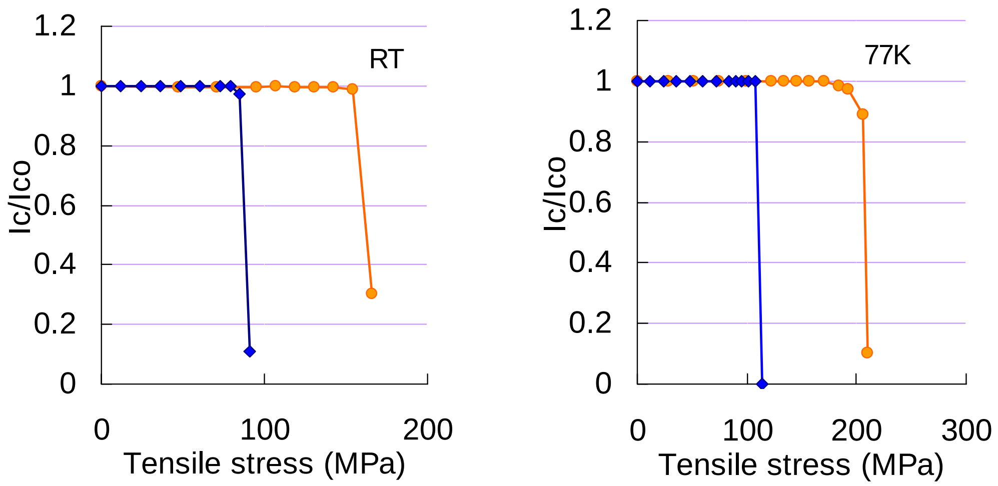


Fig. 4 Tensile stress dependence of low silver ratio wire Ic
(Left: Atmospheric-pressure sintered wire Right: Pressurized sintering)

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# Feature Articles : Superconducting Wire Technology - Development of Large-capacity Bi-2212 Wire -

Takayo Hasegawa
Superconductor Project
Showa Electric Wire & Cable Co., Ltd.

Compared with Bi-2223, Bi-2212 can achieve a high Jc free from the filament shape because the melt-solidification process is used in forming superconductors even though the Tc of Bi-2212 is low. Round wire can therefore be fabricated with Bi-2212, thereby allowing fabrication of twisted wires as in conventional metallic superconducting wires. This will be a great advantage in achieving large capacities. Jointly with Chubu Electric Power Co., Showa Electric Wire & Cable has been developing large-capacity conductors using the Bi-2212 round wire. The strand in the wire has a sectional structure as shown in Fig. 1. Uniform melt-solidification reaction is achieved collecting 427 filaments for the 0.81 mm diameter and 889 filaments for the 1.0 mm diameter to optimize the number of filaments to achieve a high Jc. This allows fabrication of superconducting round wire that maintains a high characteristic at 4.2 K in a high magnetic field. A conductor of a 500 m class obtained by twisting six strands around a NiCr center reinforcing member has been used as a conductor in a 1MVA class short-break compensation oxide SMES coil developed by Chubu Electric Power Co., Inc..


Fig. 1 Section of Bi-2212 round wire

A Rutherford-type conductor as shown in Figs. 2 and 3 has been developed as a conductor with a larger current carrying capacity. This conductor was fabricated by twisting 30 strands that were 0.81 mm in diameter (427 filaments) and then by compression molding. This conductor has been verified in a current-carrying test to carry a current exceeding 10 kA in a self magnetic field at 4.2 K. A current about one half could be flowed at 5T. These twisted wires can now be fabricated in lengths of several hundred meters after optimizing the wire twisting conditions. Almost uniform characteristics could be verified in full-length inspection in a supercooled liquid nitrogen environment even when the firing length was lengthened to 200 m.

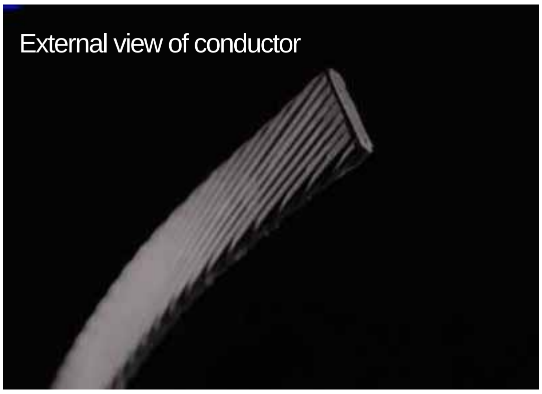

Fig. 2 External view of Rutherford-type compression molded conductor

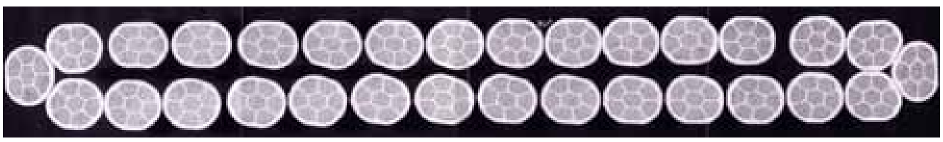
Fig. 3 Sectional view of Rutherford-type compression molded conductor

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# Feature Articles : Superconducting Wire Technology - View of Advanced $Nb_3Sn$, $Nb_3Al$ and $MgB_2$ Wires -

Hiroaki Kumakura
Superconducting Materials Center
National Institute for Materials Science

In the field of superconducting wires, wire development using so-called high-temperature oxide superconductors is being actively undertaken, achieving prominent results. Steady advances have been achieved in the field of conventional metal wires even though they tend to be hidden in the shadow of prominent activities undertaken for oxide superconductors. Research and development for specific applications has been activated. This article briefly describes recent research development of $Nb_3Sn$ and $Nb_3Al$ wires, as well as recent $MgB_2$ wires, among metallic wires.

First, commercialization of the $Nb_3Sn$ wire was accomplished by the bronze method for fabricating $Nb_3Sn$ by diffusion reaction of a Cu-Sn solid solution (bronze) and Nb. The wire has been used as wire in magnets that generate more than 10T, which cannot be achieved with Nb-Ti. Recently, Jc was increased prominently by increasing the Sn concentration to a boundary, 16%, and the wire is used in high magnetic field NMR magnets that give the priority to a high Jc characteristic, high n value and superconducting connectivity. On the other hand, the internal Sn diffusion method, which uses Sn as a cross section member in the Cu matrix in addition to Nb filaments, is inferior in AC loss property compared with the bronze method. However, the internal Sn diffusion method is now actively being researched since it can achieve a higher Jc because the Sn content can now be increased. Recently, Oxford Instruments of the United States has achieved a further improvement that satisfies a high Jc specification of the next-generation accelerator. By reducing the proportion of Cu to a minimum, high non-Cu Jc of 300,000 $A/cm^2$ at 4.2 K and 12T could be achieved. The mass producibility, which was a weakness of the internal Sn diffusion method, could be improved by hot extruding a large multi billet of 200 kg using a dummy salt in place of Sn and by then substituting the dummy salt with Sn. Improvement of RRR, suppression of flux jump and improvement of mechanical properties are important research goals for the future.

The high upper critical field and excellent mechanical properties of $Nb_3Al$ compared with $Nb_3Sn$ are great advantages of $Nb_3Al$. Wires are fabricated by rapidly heating and quenching a multi-core composite precursor of Nb/Al to obtain a supersaturated solid solution of bcc and by transforming the solid solution into $Nb_3Al$ by subsequent heat treatment. This process is called the Rapid-heating, Quenching and Transformation (RHQT) method and is attracting attention. This method features grain structures that have stoichiometric compositions and that are fine so that excellent critical current characteristics can be obtained in a high magnetic field. Other applications of $Nb_3Al$ wires include the next-generation accelerator, nuclear fusion reactor, and high magnetic field NMR. The United States is developing wires for accelerators using a DOE (Department of Energy) budget. Japan also is conducting research and development centering on KEK. The first research challenge for $Nb_3Al$ wires for accelerators is to fabricate long lengths conductors. A Nb/Al precursor wire 2600 m in length has already been fabricated, and attempts are being made to fabricate wires of longer lengths. At the same time, equipment for rapid heating and quenching of long-length wires and technology to process them is needed. A technology to stabilize wires is also important. Candidate technologies include an internal stabilization method to disperse Nb-covered Ag rods in the inside and copper ion plating/electroplating method. Furthermore, control of flux jump and optimization of transformation processing conditions to improve non-Cu Jc in the 12-15T region are important.

  

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Only three years have passed since $MgB_2$ was discovered. At present, research is being actively conducted to fabricate wires by the so-called powder in tube method. However, the research level is still at an early stage compared with $Nb_3Al$ and other materials, even though wires in a 1000 m class have already been fabricated, proving that past expectations that long lengths can be fabricated easily are accurate. Nevertheless, the Jc of long-length cables is still substantially low. $B_{c2}(B_{irr})$ appears to be greatly promising, achieving about 10T at 20 K by relatively low heat treatment in the neighborhood of 600 °C, which is similar to a value achieved by commercialized Nb-Ti wires at 4.2 K. One problem, however, is that Jc greatly depends on the magnetic field and rapidly lowers together with a magnetic field. Doping of various dopants has been attempted as a method to improve J-B characteristic of $MgB_2$ wires. Among these dopants, doping of a nanometer size SiC powder is most effective. SiC doping has achieved a Jc of 60,000 $A/cm^2$ at 3T and 20 K. These values are not satisfactory for practical use, but represent a drastic improvement in Jc compared with values achieved when $MgB_2$ was first found. There are high expectations of future advances. Pinning centers will be needed in the future. Data of thin films has suggested the crystal grain boundary as an effective pinning center and micro crystalline grains will become one research direction as in $Nb_3Sn$ and $Nb_3Al$.

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# Feature Articles : Superconducting Bulk Technology
# - Current Status of Superconducting Bulk Magnet Materials and Applications -

Masato Murakami*, Professor
Department of Materials Science and Engineering
Shibaura Institute of Technology

Bulk superconducting materials that function as superconducting magnets are RE-Ba-Cu-O (RE: rare earth elements) materials, and its principle is the trapping of magnetic fields through induced currents. The currents are induced by a change in the external magnetic fields exerted to a superconductor in that the maximum induced current is the critical current of the superconductor.

The magnitude of the trapped magnetic field is proportional to the size of the current loop together with the critical current. The high performance of superconducting bulk magnets can therefore be achieved either by an enhancement of the critical current or an increase in the sample size with texture control.

The dispersion of effective pinning centers is necessary to enhance the critical current. First, the critical current of Y-Ba-Cu-O materials is enhanced by dispersing very fine non-superconducting $Y_2BaCuO_5$ (Y211) phase particles in $YBa_2Cu_3O_7$ (Y123) superconducting matrix. A high critical current is also obtained in Nd, Sm, Eu and Gd materials that have a RE-Ba solid solution by controlling chemical compositional fluctuations in the RE123 matrix. Mixing an RE site with several elements results in the formation of nano-order sized composition fluctuations uniformly distributed in the matrix, leading to a extremely high critical current density of exceeding 200,000 A/cm$^2$ at liquid nitrogen temperature.

For the size enlargement, it is important to grow the sample without weak links such as high angle grain boundaries and cracks. For this reason, a top-seeded melt-growth technique is employed to grow a textured crystal that is c-axis oriented through the entire sample.

For high field applications, however, it has become clear that textured RE-Ba-Cu-O materials with high superconducting performances are not sufficient. This is because a large electromagnetic force acts on the material, which leads to the fracture when a high magnetic field is trapped partly due to poor mechanical properties. Thermal conductivities of oxide superconductors are also small, which reduced the cryo-stability of the bulk magnets. Hence heat generated inside the superconductors results in quenching and fracture.

Several techniques have been developed to enhance the mechanical properties and the cryo-stability. Ag doping, resin impregnation, encapsulation with a metal ring and other techniques are known to be effective in enhancing mechanical properties. A technique to impregnate an alloy (Bi-Pb-Sn-Cd) with a low melting temperature after inserting Al rods with excellent thermal conductivity into artificial holes drilled in the sample has been found to be effective in improving the cryo-stability. A trapped magnetic field of 17T at 29K has been accomplished with a Y-Ba-Cu-O 2.5 cm in diameter treated with the alloy impregnation.

Thus, the bulk superconducting magnets can generate high magnetic fields that cannot be generated by conventional permanent magnets. The applications of bulk superconductors are grouped roughly into three fields: magnetic levitation; magnet; and conductor applications. The current status and the problems surrounding magnet applications are summarized below.

At present, permanent magnets are widely used for power equipment and electronic components. However, upper limits of magnetic fields are intrinsically imposed on permanent magnets due to the spin of elements. Trapped magnetic fields of bulk superconducting magnets can be enhanced arbitrarily if the critical current can be increased, and the magnetic fields larger than 10T are already available. Therefore, power devices that use permanent magnets can be made compact and the output can greatly be increased. Unlike superconducting coils, a high magnetic field can be generated in a very small area and furthermore a high magnetic field gradient can easily be achieved, and a typical application utilizing these characteristics is a magnetic separation system for water purification.

The characteristic of a bulk magnet differentiating from a superconducting coil is that the field cannot be generated by passing currents, and instead it must be field-cooled in the presence of the magnetic field inside the bore of a superconducting magnet or be excited by applying a pulsed magnetic field. The activation is not the problem for the applications where a superconducting magnet can be used as a magnetic source. In contrast, the trapped field capability is significantly reduced with the heat generated during the pulse field activation process, and therefore, the enhancement of the field trapping ability of the bulk magnet with the pulse field excitation is a major challenge.

* Professor Murakami is concurrently a fellow at SRL/ISTEC.

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## Feature Articles : Superconducting Bulk Technology
## - Development of Superconducting Magnetic Bearing for 100 kWh-class Flywheel Energy Storage System -

The establishment of a superconducting magnetic bearing (SMB) technology that uses a high-temperature superconducting bulk magnet to support a heavy rotor which rotates at a high-speed without contact causing low rotational loss is needed to commercialize flywheel energy storage systems (FESSs). Under a project for R&D of SMB technologies for FESSs supported by NEDO (New Energy and Industrial Technology Development Organization), an SMB model for 100 kWh-class FESS was developed and performance of it was evaluated to assess technical feasibilities on the manufacture of radial SMBs suitable for high capacities.

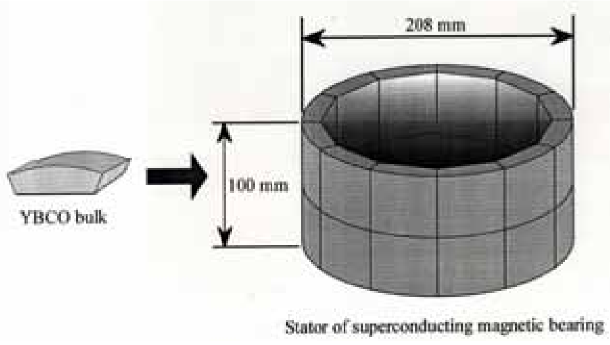


Fig. 1 Bulk arrangement inside the stator of a 100 kWh-class SMB model

The SMB stator model was fabricated by fixing 24 bulks arranged as shown in Fig. 1 by bonding them with an adhesive on the inner walls of a cylindrical cryostat with 1 mm in thickness. The actual 100 kWh bearing is to be fabricated by stacking 7 to 9 of this model axially. Each bulk was vacuum-impregnated with an epoxy resin to enhance the mechanical characteristics and durability. A high magnetic field of the SMB rotor (Fig.2) was achieved by tapering the yoke between permanent magnets radially. Through these measures, the peak magnetic field intensity was improved by about 20% compared with a conventional structure. The gap between the stator and rotor was 1.8 mm (air gap 0.8 mm).

Fig. 2 Tapered 300 mm diameter magnetic circuit

The performance evaluation of SMB showed a levitation force density of 11 N/cm$^2$ at 77K (17 N/cm$^2$@67K) exceeding the targeted 10 N/cm$^2$. As a counter measure to suppress the rotor fall, which is indispensable in making the bearing feasible, effects of a pre-loading method and a supercooling method were verified. Additionally, a post-supercooling method was newly proposed and its effectiveness was confirmed.

Through these evaluations, the technical feasibilities of a radial SMB for a 100 kWh-class FESS were confirmed.

(Takumi Ichihara, Planning & Management Department, Bulk Superconductor Laboratory, Division of Material Science & Physics, SRL/ISTEC)

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# Feature Articles : Superconducting Bulk Technology - Superconducting Motor with Liquid Nitrogen Cooled Bulk Superconductors as Rotating Pole-field Magnets -

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

The advantages gained by mounting a bulk high-temperature superconductor (HTS) in equipment as a pole-field magnet are the elimination of connection of current leads for excitation and non-supply of additional energy for maintaining a magnetic field. On the other hand, a current lead is needed for excitation when a superconducting wire coil is used. To maintain the magnetic field, the power has to be continuously supplied to high-temperature superconducting wire under production in large quantities. A bulk HTS provides a large magnetic filed with small area around the size of the bulk. The group of Kitano Seiki, Tokyo University of Marine Science and Technology and Fukui University has designed and fabricated a brushless synchronous motor that has eight Gd-Ba-Cu-O bulk magnets on the rotor as field poles and that turns monolithically with the output shaft. The motor is 500 mm in outside diameter and 300 mm in length with a design specification of 15 kW and 720 rpm. Six coreless vortex-type armature coils are fixed on both sides of the rotor, on which eight bulk magnets are placed on the circumference of the rotor (see Fig. 1). The bulk magnets impress a pulsed current to the vortex coils in a split arrangement and magnetized by a pulsed magnetic field. The rotor and armature are alternately placed in the direction of the output shaft to increase the capacity. Only cabling to the armature needs be considered as in permanent magnet motors and this provides an excellent redundancy.

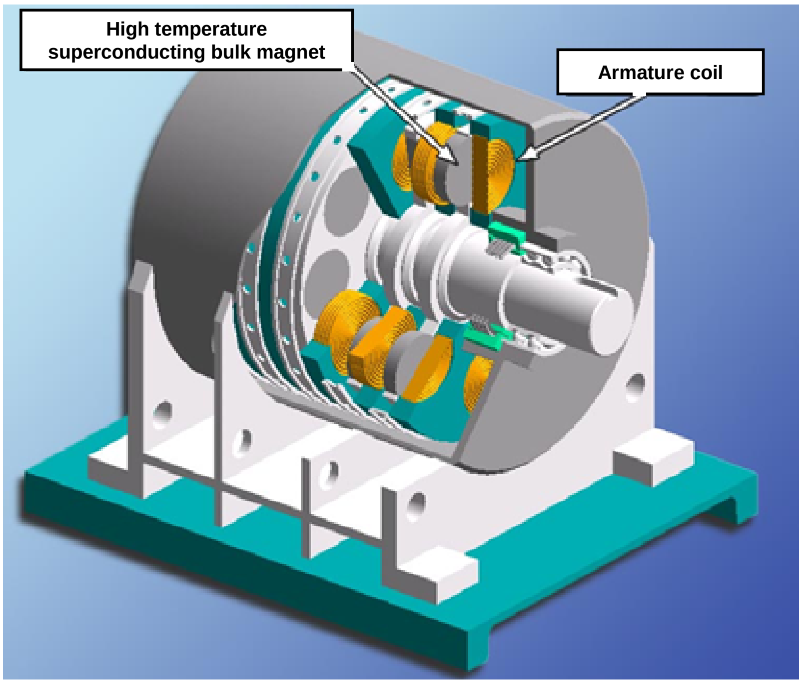


Fig. 1 Schematic diagram of revolving field multi-layered high-torque superconducting motor

A coolant (liquid nitrogen at present) is circulated inside the rotor that is in the unit inside of the rotor mounted with the bulk magnets to achieve efficient cooling commensurate with the material properties of Gd bulks. A rotary joint was developed for this purpose to feed a coolant into the rotor and to circulate around the eight bulks. The approach to this coolant circulation cooling mechanism is intrinsically the same as that of the high-temperature superconducting motors announced by AMSC of the United States and Siemens of Germany. The rotor is thermally insulated from the ambience and the air gap between the surfaces of the bulks and fixed armature is thermally insulated by a high vacuum. The bulks are not

  

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dipped in a coolant. In the past, verification results at 3 kW and 720 rpm have been announced. Since then, high torques have been achieved by increasing the trapped fluxes of fields of the mounted bulks to experiment: (1) Optimal control of pulsed magnetization waveform and pulsed magnetization to quickly start the motor and (2) Mounting of composite bulk magnets aimed for maximizing magnetic fluxes on both front and back surfaces and making distribution of the pinning centers uniform. During the pulsed magnetization, momentary repulsion applies to the rotor and output shaft as a torsional moment. After developing a magnetization mechanism to avoid this impact, magnetization can be performed more than once without any problem.

In the past six months, the trapped magnetic fluxes have increased more than 60% inside the motor and drastic improvement in trapped magnetic fluxes by metal impregnation in the bulks has been verified. Experiments have been conducted to improve the trapped magnetic fluxes by nano-particle dispersion of the second phase. Further increases in torque are possible in the future. The key to commercialization of more compact, lighter and high-torque motors depend on accomplishing an air gap field that drastically surpasses that of permanent magnet fields and effective cooling of pole-field HTS bulk magnets by a in-frame closed cycle cooling without coolant supply from outside, which leads to further enhancement of pole field. Bulk magnets of large diameters are effective to increase capacities of bulk superconducting motors. In this respect, the development of a bulk magnet 140 mm in diameter by ISTEC is a great stimulus. Peripheral and element technologies of bulk superconducting motors are widely studied for application to not only the energy and transport field as low-speed multi-pole machines, but also the medical field and ocean environment conservation field.

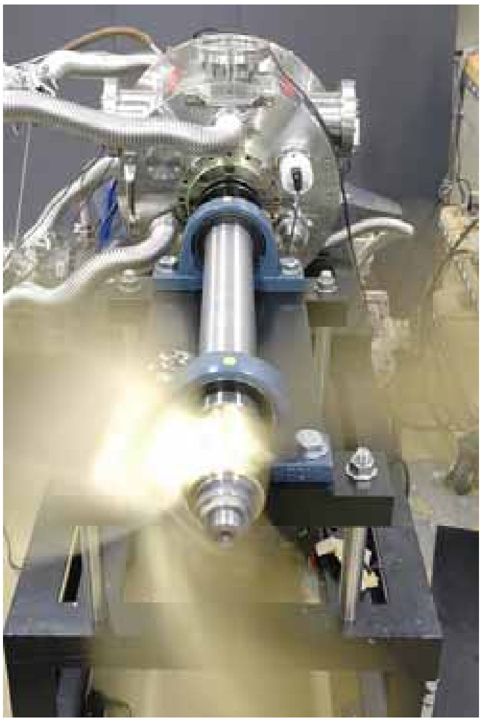

Fig. 2 Bulk superconducting motor in verification experiment of propeller revolutions

Part of this research is subsidized by the technology development fund of the Ship and Ocean Foundation financed by The Nippon Foundation. In addition to the foregoing three organizations, Fuji Electric Systems, Hitachi Metals, Kamome Propellers, Nippon Steel Advanced Technology Research Laboratory, Shibaura Institute of Technology and Superconductivity Research Laboratory of International Superconductivity Technology Center (ISTEC-SRL) have cooperated in this project.

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# Feature Articles : Superconducting Bulk Technology
# - Application to Magnetron Sputtering System -

Uichiro Mizutani,
Toyota Physical & Chemical Research Institute

$REBa_2Cu_3O_{7-d}$ (RE = Sm, Gd, etc.), or so-called RE123 superconducting materials, feature a high critical current density Jc even in a high magnetic field thanks to the presence of pinning points such as non-superconducting 211 particles. A superconducting current continues to flow throughout the bulk after demagnetization, allowing it to be used as a strong pseudopermanent magnet. For example, a bulk superconductor 60 mm in diameter can generate a magnetic field exceeding 5 Tesla on its surfaces. Furthermore, the Jc of RE123 superconducting materials increases when the temperature is lowered. Indeed, commercialization of them can be significantly accelerated by embedding superconducting bulks in a compact refrigerator and making it a magnetic field source integral with a refrigerator by cooling them to 20 to 30 K, rather than remaining in cooling to 77 K by liquid nitrogen. Our group has conducted experiments using Sm bulks 60 mm in diameter fabricated by the group and Gd bulks 60 mm in diameter sold on the market. A magnetic field of 6.0 to 6.5 T has been obtained in a room-temperature space 3 mm above bulk surfaces by installing them in an air-cooled refrigerator and magnetizing them after cooling them to 27 K in a static magnetic field of 8.5 T.

These magnetized superconducting bulks can be moved to any place while the refrigerator is run using a hybrid vehicle that has a car-borne power source. Figure 1 shows the magnetron sputtering system installed with superconducting bulk magnets that we developed. Thanks to superconducting bulk magnets, the level of the horizontal magnetic field component on the target is 1.2 T, which is more than 20 times the value of 0.05 T that is achieved by ordinary magnetron sputtering systems. Therefore, discharges can be maintained under argon pressure of 0.1 to 0.01 Pa, which is one or two orders lower than before. By lowering the pressure during film deposition, the average free stroke of sputter particles greatly extends from less than 10 cm in the past to more than 50 cm, thereby improving the straightness of the sputter particles and allowing film deposition even if the distance between the target and substrate is increased to several ten cm or more. This low pressure and long distance film deposition allows film deposition inside via holes of a high aspect ratio and film deposition with less plasma damage.

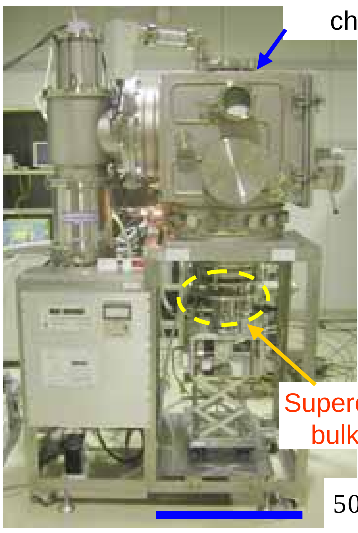


Fig. 1 High magnetic field magnetron sputtering system

Under the 3-year project Innovation Plaza Tokai of Japan Science and Technology Agency, research to develop a system to deposit optical multilayer films used in next-generation semiconductor exposure system using extreme ultraviolet ray (EUV) has been started beginning this year jointly with Nagoya University, Nikon and IMRA Material Development Research Institute.

A multilayer film mirror for EUV is a stack of about 50 layers, alternately stacking Mo 2.5 nm in film thickness and Si 4.5 nm in film thickness. When a diffusion layer more than 1 nm in thickness is formed on their interfaces, the reflectivity can never reach the theoretical value. The exposure system exposes circuits on a Si wafer through more than ten mirrors. By improving the reflectivity of each mirror by 3%, for example, the total transmittance can be improved by as much as 70%. We are expecting reductions in diffusion layers to drastically reduce the exposure time. Research has been started to obtain optical multilayer films of a high reflectivity with thinner interfacial diffusion layers and with drastically less plasma damage by using a magnetron sputtering system that uses superconducting bulk magnets.

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# Patent Information

## Introduction of Published Unexamined Patents in the 4th Quarter of Fiscal 2004

The following are ISTEC's patents published from January through March 2005. For more information, access the homepage of Japan Patent Office and visit the Industrial Property Digital Library (IPDL) or other patent databases.

**1) Publication No. 2005-39244: "Electronic Devices and Method to Form Multilayer Wiring for Them"**

This invention relates to a method to manufacture multilayer wiring of superconducting electronic devices and is especially effective when it is applied to superconducting IC devices. In the ordinary multilayer wiring method that forms an upper wiring layer through an insulation layer leaving intact steps of wiring patterns in lower wiring layer, more disconnections and short-circuits are caused the greater the number of layers, thereby considerably deteriorating the wiring yield. This invention forms a flat wiring layer by covering the wiring patterns of the previous layer with an embedding layer of about the same thickness as that of the previous wiring layer and by selectively removing the embedded layer using an inverse pattern mask of the previous wiring layer, that is, by filling dented parts of the previous wiring patterns with the embedding layer, and then forming an insulation layer. Multilayer-wiring is realized by repeating plural these procedures. This method allows multilayer-wiring with a large process margin, independent of pattern dimensions and pattern density, implementing a device fabrication process with high reliability.

**2) Publication No. 2005-50846: "High-temperature Superconducting Devices"**

In design of Josephson-junction loops in the single flux quantum circuits(SFQ circuits) operating at high speed, the product of the loop inductance(L) and junction critical current($I_c$) is required to equal one flux quantum $\Phi_o$, and the product of $I_c$ of the junction and normal conduction resistance $R_n$ is required to be as large as possible. Under the latter condition, a junction with high $I_c$ and a narrow width is preferable. However, this increases L and no longer satisfies the former condition. In this invention, one electrode of a lamp edge junction is implemented by configuring in 2-layer structure of the first electrode layer defining the junction width and the second electrode layer whose width is wider than the first layer. The structure allows the first and second layers to be partially contacted and the remains except the contacted area isolated by an insulating layer, thereby realizing an electrode with a junction of a narrow width and with small inductance.

**3) Publication No. 2005-79749: "Superconducting Circuits and Superconducting SFQ Logic Circuits"**

This invention relates to a latch-type interface circuits in superconducting IC circuits and features a superconducting loop comprised by connecting an SFQ buffer gate of DC bias current and a high-voltage Josephson gate of AC bias current through a large inductance enough to store SFQ pulses. The high-voltage Josephson gate is connected plural Josephson junctions and resistances serially and in parallel to amplify an SFQ pulse. In this system, only the high-voltage Josephson gate requires an AC bias current, reducing ground ripples. Even if an SFQ pulse arrives at the SFQ buffer gate earlier than the rising edge of an AC bias current, the timing margin increases because the SFQ pulse is retained in the superconducting loop.

(Katsuo Nakazato, Director, Research & Development Promotion Division, SRL/ISTEC)

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## Standardization Activities

### Topics in March
### - JIS H 7306 (RRR test method for NbTi composite superconductors) and JIS H 7307 (Test method for surface resistance of superconducting thin films) issued -

An announcement by the Japanese Standards Association on February 20 2005 on the issuance of the following two JIS (Japanese Industrial Standards) standards related to superconductivity was published in the official gazette of February 21.

Title: Superconductivity - Residual resistance ratio measurement - Residual resistance ratio of Nb-Ti composite superconductors
Standard No.: JIS H 7306
Date Established: February 20 2005
Issued By: Japanese Standards Association
Organization of Standard: Standards body; introduction, scope, normative reference, definitions, requirements, system, sample preparation, test method, precision and accuracy of test method, reporting matters, Annex A and explanations.

Overview of test method: Measuring methods of residual resistance ratio, RRR are specified for Nb-Ti composite superconductors having a rectangular or circular cross section less than 350 in RRR and 3 $mm^2$ in sectional area based on the ratio of electrical resistance at room temperature and the resistance directly above superconducting transition.

Draft Standard Compiled By: The draft was compiled by installing the JIS Draft Compilation WG4 (supervisor: Prof. Teruo Matsushita, Kyushu Institute of Technology) under JIS Draft Compilation Committee (chairman: Prof. Kozo Osamura, Kyoto University).

International Standard Alignment: IEC 61788-4 (2001) Superconductivity - Part 4: Residual resistance ratio measurement - Residual resistance ratio of Nb-Ti composite superconductors

Title: Superconductivity – Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies
Standard No.: JIS H 7307
Date Established: February 20 2005
Issued By: Japanese Standards Association
Organization of Standard: Standards body; introduction, scope, normative reference, glossary and definitions, requirements, theory and calculation formula, system, test method, precision and accuracy of test method, reporting matters, Annex A and explanations.

Overview of test method: Test methods of superconductor surface resistance in the microwave band using a standard 2-resonator method are specified. Frequency is set at $8 \text{ GHz} < f < 30 \text{ GHz}$ and measuring resolution is set 0.01 mΩ at 10 GHz.

Draft Standard Compiled By: The draft was compiled by installing the JIS Draft Compilation WG8 (supervisor: Mr. Shin Kosaka, National Institute for Advanced Industrial Science and Technology) under JIS Draft Compilation Committee (chairman: Prof. Kozo Osamura, Kyoto University).

International Standard Alignment: IEC 61788-7 (2002) Superconductivity - Part 7: Electronics characteristic measurements - Surface resistance of superconductors at microwave frequencies

Order copies of JIS standards directly from:
Japanese Standards Association
4-1-24 Akasaka, Minato-ku, Tokyo 107-8440, Japan
Tel. 03-3583-8071 +81-3-3583-8071 Fax 03-3582-3372 +81-3-3582-3372
Web store (http://www.jsa.or.jp)

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## Topics in April
## - JIS H 7005 (Electrotechnical Vocabulary - Superconductivity) 2005 revision issued -

In conjunction with deliberations conducted by the Japanese Industrial Standards Committee, the Japanese Standards Association revised and issued the following JIS standard related to superconductivity on March 20 2005.

Title: Electrotechnical Vocabulary - Superconductivity
Standard No.: JIS H 7005: 2005
Date Established: March 20 2005
Issued By: Japanese Standards Association
Organization of Standard: Standards body; introduction, scope, normative reference, terms and definitions, explanations, index by Japanese syllabary and index in alphabetical order.

Overview of revised terms: This standard is a revision to JIS H 7005: 1999 Revision (Electrotechnical Vocabulary - Superconductivity) which revised the first edition of JIS H 7005 (Electrotechnical Vocabulary - Superconductivity) 1991. The latest revision contains the following three main topics:
(1) Securing of alignment with IEC 60050-815: 2000
(2) Addition of new terms related to high-temperature superconductivity
(3) Corrections related to maintenance of IEC 60050-815: 2000

Draft Standard Prepared By: The draft was compiled by installing the JIS Draft Compilation WG1 (supervisor: Prof. Rikuro Ogawa, Hakodate Technical College) under JIS Draft Compilation Committee (chairman: Prof. Kozo Osamura, Kyoto University).

Order copies of JIS standards directly from:
Japanese Standards Association
4-1-24 Akasaka, Minato-ku, Tokyo 107-8440, Japan
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(Yasuzo Tanaka, Director, Standardization Department, ISTEC)

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