Fall, 2008 Date of Issue: October 8, 2008

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

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超電導 Web21 Superconductivity

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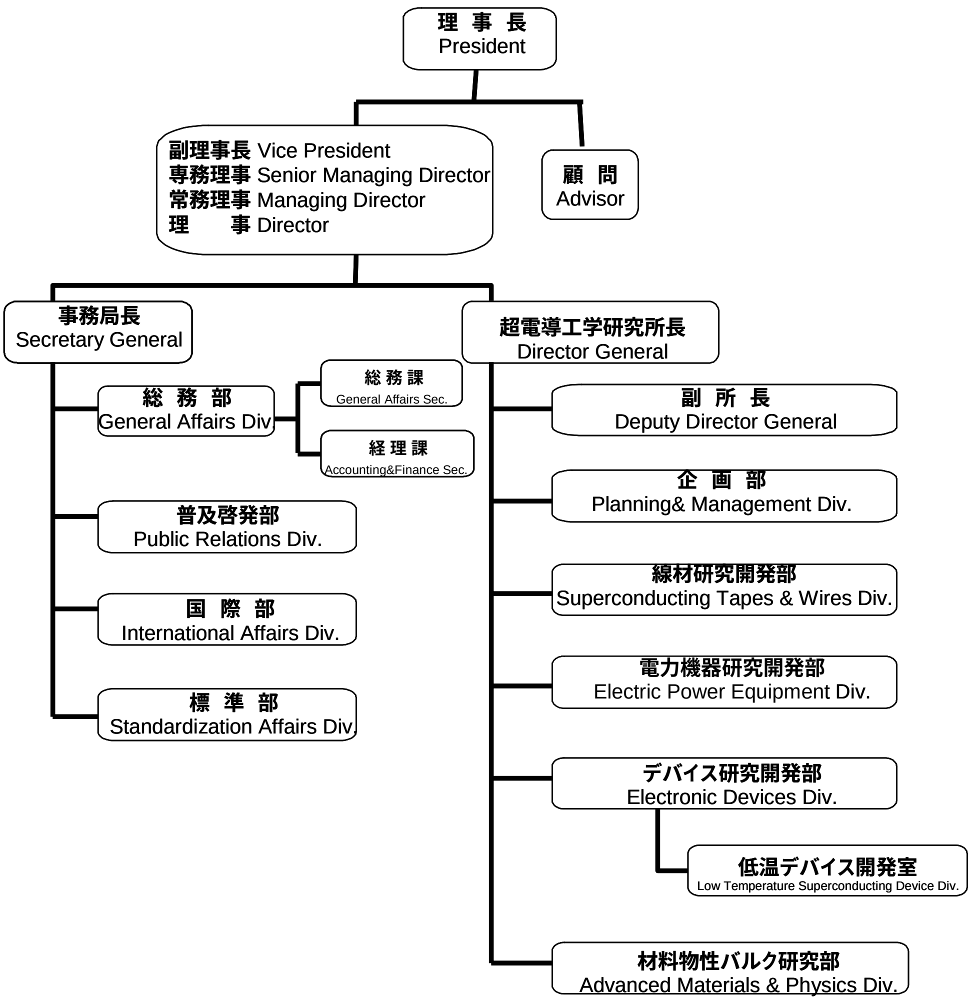
International Superconductivity Technology Center Moves to Toyosu, Koto-ku

On July 1, 2008, the International Superconductivity Technology Center (President: Hiroshi Araki) resumed normal operations at the new address noted below. The contact information for the organization has been changed as follows as a result of the move.

New address

1-10-13 Shinonome, Koto-ku, Tokyo
135-0062, Japan
Phone: +81-3-3536-5703
(Shared location with the Superconductivity Research Laboratory)
Nearest station:
Ten-minute walk from exit 5 of Toyosu Station on the Tokyo Metro Yurakucho Line.

New organization



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New contact information

Department	Phone	Fax
General Affairs Div. (general info)	+81-3-3536-5703	+81-3-3536-5717
Public Relations Div. (former Research and Planning Dept.)*.	+81-3-3536-7283	+81-3-3536-7318
International Affairs Div	+81-3-3536-7284	+81-3-3536-7318
Standardization Affairs Div	+81-3-3536-7264	+81-3-3536-7318
IEC/TC90 Superconductivity Committee	+81-3-3536-7214	+81-3-3536-7318
Planning & Management Div	+81-3-3536-7327	+81-3-3536-5714
Superconducting Tapes & Wires Div	+81-3-3536-5711	+81-3-3536-8311
Electric Power Equipment Div	+81-3-3536-5702	+81-3-3536-5705
Electronic Devices Div	+81-3-3536-5709	+81-3-3536-5705
Advanced Materials & Physics Div	+81-3-3536-5707	+81-3-3536-5705

* Chodendo Web21 Editorial Office

(Editorial Office)

(Published in a Japanese version in the July 2008 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

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11th IEC/TC90 (Superconductivity) International Conference Held in Berlin

The 11th international conference of the IEC/TC90 (Superconductivity, Technical Committee 90, International Electrotechnical Commission) was held from June 9 to 11, 2008 at VDE Haus in Berlin. A total of 32 representatives, specifically two from China, 10 from Germany, five from South Korea, one from Poland, 11 from Japan, one from the U.S. (Conference Chair), one from Switzerland (Central Office) and one from Sweden (observer), were in attendance, and the conference concluded with great success.

In recent years, the international conference of the IEC/TC90 has been held in Asia, Europe, and the U.S. every two years on a rotating basis. The 10th conference was held in Kyoto, while the latest conference, the 11th one so far, was held this year in Berlin. The conference consisted of working group meetings (June 9 and 10), mini-symposiums (June 10), the plenary session (June 11), and a social event (June 10). The conference meetings and events were held in accordance with the IEC conference manual.

Seven working group meetings (WG1, WG4, WG5, WG8, WG9, WG11, and WG12) were held on June 9 and 10, and during these meetings, deliberations were carried out on superconductivity terminology standards and maintenance proposals for test method standards. Based on the agreement reached at the 10th conference held in Kyoto, there was a particularly lively exchange of ideas concerning problem points specific to each working group in regards to the uncertainty toward superconductivity-related standards

The mini-symposiums on June 10 were something completely new held on a trial basis. The topics they covered consisted of superconducting cables, VAMAS activity, uncertainty, and superconducting wire. Participants deepened their understanding of superconducting technology and standardization-related knowledge and engaged in a lively exchange of ideas concerning the future expansion into standardization activities. There was a particularly lively exchange of information with the IEC/TC90 and Mr. Fredrik Ruter, chair of the SC B1 (Insulated Cables) Committee of CIGRE (International Council on Large Electric Systems), and this proved useful for future standardization activities.

Mini-symposium (Kozo Osamura making a proposal for superconducting wire)

On June 11th, following chairman Loren F. Goodrich's opening declaration of the IEC/TC90 international conference, Mr. Stefan Emde of VDE/DKE offered some words of greeting to the IEC/TC90 Berlin conference and stated his expectations regarding IEC/TC90's efforts. This was followed by a confirmation of the topics to be discussed, a confirmation of the meeting minutes of the previous conference held in Kyoto, a progress report on deliberations items, approvals of seven maintenance items, and a report on standardization efforts in each country. Korea reported on international standardization efforts along with domestic standardization efforts, including those for superconducting cables.

In addition, deliberation approval was given for two new items proposed by Japan, namely "Test Methods for Nondestructive Current Density" and "Test Methods for High-Powered Microwaves." Furthermore, in regards to the future direction of standardization, first, approval was given for a proposal to establish a working group within CIGRE for superconducting cables and then for establishing a new ad-hoc group within TC90 for superconducting wire.

Finally, a three-year extension of the chairman's term was approved, and a basic agreement was reached on holding the 12th international conference jointly with the 75th IEC General Meeting from October 6 to 15, 2010 in Seattle.

Greeting from Stefan Emde (VDE/DKE) and view of plenary session

(Yasuzo Tanaka, Director, Standardization Affairs Div. ISTEC)

(Published in a Japanese version in the July 2008 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

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What's New in the World of Superconductivity (August)

Award

Oxford Instruments (August 6, 2008)

Sir Martin Wood, founder of Oxford Instruments (U.K.), has been awarded the Institute of Electrical and Electronics Engineers (IEEE) Max Swerdlow Award for Sustained Service to the Applied Superconductivity Community. This award was established to recognize sustained service to the applied superconductivity community resulting in a lasting influence on the advancement of this technology. Sir Martin Wood was particularly recognized for his innovative and bold approach to the commercialization of superconducting magnets and magnet systems, resulting in the founding of Oxford Instruments—a worldwide leader in superconductivity technology. The award was presented to Sir Martin Wood at a ceremony held during the 2008 Applied Superconductivity Conference in Chicago, USA.

Source:
"Sir Martin Wood receives award for outstanding contribution to the field of applied superconductivity"
Oxford Instruments press release (August 6, 2008)
http://www.oxford-instruments.com/wps/wcm/connect/Oxford+Instruments/Internet/Press/Current+News/Sir+Martin+Wood+receives+award+for+outstanding+contribution+to+the+field+of+applied+superconductivity

Power

Ames Laboratory (August 15, 2008)

John R. Clem, a physicist at the U.S. Department of Energy (DOE)'s Ames Laboratory, has developed some new design strategies for superconducting fault-current limiters (FCLs) that may help to reduce the costs and improve the efficiency of bifilar FCLs. Clem explained, "I was able to theoretically confirm that planned design changes to the current bifilar fault-current limiter being developed by Siemens and American Superconductor would decrease AC losses in the system." The project that Clem is referring to is a DOE contract to demonstrate superconducting FCLs at transmission voltages in Southern California Edison's power grid. Nexans and Air Liquide are also involved in this project. The present bifilar design utilizes a layout where adjacent superconducting tapes in a pancake coil carry current in opposite directions, effectively canceling each tape's magnetic field and limiting electrical losses. Siemens and American Superconductor asked Clem to predict how AC losses would change if the width of the tapes was increased. Alex Malozemoff, chief technical officer of American Superconductor, reported, "It turns out that for typical parameters, when the spacing between adjacent tapes is small enough, the result is very simple: AC losses decrease as the tape width increases and the spacing decreases." Siemens and American Superconductor will use these important results to optimize the design of their bifilar FCL. Clem's findings were reported in a recent issue of *Physical Review B*. The DOE's Office of Science, Basic Energy Sciences Office, provided funding for this research.

Source
"Ames laboratory physicist develops 'electrifying' theory"
Ames Laboratory press release (August 15, 2008)
http://www.external.ameslab.gov/final/News/2008rel/Clem.html

American Superconductor Corporation (August 5, 2008)

American Superconductor Corporation (AMSC) has reported its financial results for its first fiscal quarter ending June 30, 2008. Revenues for the first quarter reached a record US $ 39.8 million, representing a 101 % increase from the $19.8 million reported for the same period in the previous fiscal year. The gross margin for the first quarter was 29.2 %, compared with 18.1 % for the same period in the previous fiscal year. The net loss for the quarter was $6.1 million, compared with a net loss of $9.7 million for the same period in the previous fiscal year. The net loss included a non-cash charge of $2.4 million for a market-to-market adjustment on an outstanding warrant driven by the increase in the company's stock price during the quarter. The company's earnings before interest, taxes, other income and expense, depreciation, amortization, and stock-based compensation (EBITDAS) was a positive $1.7 million for the first quarter, compared with a negative $5.3 million for the same period in the previous fiscal year. AMSC generated a record $3.2 million in cash from operations for the first quarter of fiscal 2008. Cash, cash equivalents, marketable securities and restricted cash as of June 30, 2008, amounted to $131.5 million. The reported backlog at the end of the quarter was approximately $634 million, compared with $173 million as of June 30, 2007.

Source:
"AMSC Reports First Quarter Financial Results"
American Superconductor Corporation press release (August 5, 2008)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1183477&highlight

American Superconductor Corporation (August 6, 2008)

American Superconductor Corporation (AMSC) has announced the licensing of AMSC's proprietary WT1650 wind turbine design to Model Enerji, Ltd., Turkey's first megawatt-class wind turbine manufacturer. Under the terms of the contract, Model Enerji will have exclusive rights to manufacture, sell, install, operate, and maintain the WT1650 in Turkey as well as non-exclusive rights for the surrounding Mediterranean and Eastern European countries. Model Enerji plans to have its first 1.65 MW prototype installed and commissioned by mid-2009 and hopes to begin producing the turbines by the end of 2009. M. Celal Keki, General Manager of Model Enerji, commented, "Because of its vast wind resources, open terrain and industrial infrastructure, Turkey is predicted to be among the world's fastest growing wind energy markets. Our highly experienced management team has extensive expertise in Turkey's energy industry. Utilizing AMSC Windtec's designs and expertise, our company will be the first wind turbine manufacturer in Turkey and is ideally positioned to capitalize on this advancing market." In addition to an upfront license fee, AMSC will also receive a royalty payment for the first 425 WT1650 wind turbines manufactured by Model Enerji.

Turkey's wind power capacity grew 198 % to 146 MW in 2007, and 12 additional licensed projects with a capacity of over 600 MW are expected to be finalized by the end of 2009. The Turkish Energy Market Regulatory Agency is expected to offer licenses for up to 10,000 MW of wind energy in the years ahead and says that 30,000 MW may eventually be feasible.

Source:
"AMSC Enters Power Market in Turkey with Wind Turbine License to Model Enerji Ltd."
American Superconductor Corporation press release (August 6, 2008)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1184160&highlight

SuperPower (August 6, 2008)

SuperPower has reported a number of new milestone achievements and a world-record performance at the 2008 U.S. Department of Energy (DOE) Annual Peer Review of Superconductivity for Electric Systems. SuperPower chief technology officer, Dr. Venkat Selvamanickam, reported, "We have now successfully produced the world's first kilometer long complete second-generation (2G) high-temperature superconducting (HTS) wire with a 1,311 meter long segment fabricated at our manufacturing plant in Schenectady, New York. The wire carried a minimum current of 153 amperes (A), resulting in a world-record wire performance of 200,580 amp-meters. This exceeds our previous world record of 158,950 reported in March 2008." The world-record wire was produced using a high-speed throughput process and exhibits excellent uniformity over long lengths. In addition, the wire carried a minimum critical current of 200 A/cm over a 945 meter segment, yielding another world record of 189,000 amp-meters. SuperPower also reported improvements in in-field wire performance as a result of a new doping formula used during the superconductor deposition process; specifically, a critical current of 229 A/cm was achieved at 77 K, 1 T, and a critical current of 340 A/cm was achieved at 65 K, 3 T. Both of these values are twice as high as those reported in 2007. SuperPower is now also routinely producing complete five-layer buffer wire templates in lengths of 1,300 to 1,500 meters. In addition, the company has developed an industrial-scale process for producing multifilamentary wire for motor, generator, and transformer applications where low AC loses are critical; they are presently producing 15-m lengths of this new wire using a continuous process. Finally, SuperPower also reported the receipt of two National Federal Laboratory Consortium (FLC) awards, one for the successful transfer of ion beam assisted deposition (IBAD) technology in conjunction with Los Alamos National Laboratory and the other for the successful transfer of buffer technology from Oak Ridge National Laboratory.

In a related announcement, SuperPower commented on the progress of the Superconducting Fault Current Limiter (SFCL) program presently underway at SuperPower. Charles Weber, director of HTS devices at SuperPower, said, "...significant progress has been made in demonstrating that our 2G wire is the best material available for Fault Current Limiter (FCL) technology. We have proven that SuperPower's 2G wires can withstand the tremendous thermal, mechanical and electrical forces present in the FCL application, including the ability of the HTS material to recover to the superconducting state while carrying load current. This capability enables the utility customer to keep the device online while it recovers to the low impedance state after a fault. We believe we are the only organization in the world to have demonstrated this capability to date." The SFCL project is being funded by the DOE and the Electric Power Research Institute (EPRI), along with project partners, SuperPower, Sumitomo Electric Industries and host utility American Electric Power (AEP).

Source:
"SuperPower reports recent achievements at annual U.S. Department of Energy Peer Review"
SuperPower press release (August 6, 2008)
http://www.superpower-inc.com/news.php?n=157

Zenergy Power plc (August 18, 2008)

Zenergy Power plc has announced the beginning of a major extension to its manufacturing facilities in Rheinbach, Germany. The extension will significantly improve the capacity of the facility, thereby accommodating the anticipated increase in the volume production of the company's HTS induction heater. The potential market for induction heaters is estimated at €2 billion per annum, and Zenergy has already received two commercial orders for its HTS induction heater from two different global metals producers. The extension to the manufacturing facility will also increase the company's ability to manufacture HTS magnets for fault current limiters as well as coils and second-generation HTS wires. The extension to the manufacturing facility will be compliant with all European Union energy efficiency standards for industrial plants, and the power supplied to the plant will be 100 % renewably generated.

Source:

"Extension of Manufacturing Facilities"
Zenergy Power plc press release (August 18, 2008)
http://www.zenergypower.com/images/press_releases/2008-08-18-factory-extension.pdf

Material

SCI Engineered Materials, Inc. (August 5, 2008)

SCI Engineered Materials, Inc. has announced their financial results for the second quarter ending June 30, 2008. The company's revenues were $1,517,513 for the second quarter, compared with $3,403,742 for the same period in the previous fiscal year. The company's earnings before interest, income taxes, depreciation and amortization ("EBITDA") were $11,138 for the quarter, compared with $181,962 for the same period in the previous fiscal year. The gross profit margin increased to 28.9 % of total revenues for the second quarter of 2008, compared with 15.1 % for the same period in 2007. The backlog as of June 30, 2008, was $2.7 million, compared with $2.0 million as of June 30, 2007. Dan Rooney, Chairman, President and Chief Executive Officer, stated, "Our second quarter results reflect increased expenses as we continue to aggressively pursue opportunities in the Semiconductor and Thin Film Solar markets, and a decline in gross profit due to lower revenues attributable to a high value raw material. Although our total revenues were not what we had hoped for, bookings strengthened significantly during the second quarter. Backlog increased 80 % to $2.7 million at June 30, 2008 compared to March 31, 2008, positioning us for improved performance during the second half of this year."
Source:
"SCI Engineered Materials, Inc. Reports Second Quarter 2008 Results"
SCI Engineered Materials, Inc. press release (August 5, 2008)
http://www.sciengineeredmaterials.com/investors/ne/earnings/scci28.htm

SCI Engineered Materials, Inc. (August 8, 2008)

SCI Engineered Materials, Inc. has announced that its stock symbol has changed to "SCIA", effective immediately. The company's common stock is traded on the Over-The-Counter Bulletin Board market. The company's previous stock symbol was "SCCI".
Source:
"SCI Engineered Materials, Inc. Ticker Symbol Changes to 'SCIA'"
SCI Engineered Materials, Inc. press release (August 8, 2008)
http://www.sciengineeredmaterials.com/investors/ne/news/scia080808.htm

SCI Engineered Materials, Inc. (August 18, 2008)

SCI Engineered Materials, Inc. has received a two-year contract from the U.S. Department of Energy (DOE) for Phase II of a Small Business Innovation Research (SBIR) project titled "Flux Pinning Additions to Increase J_c Performance in BSCCO-2212 Round Wire for Very High Field Magnets." SCI Engineered Materials' proposal included a funding request for approximately US $750,000. However, the final amount of the award is subject to the completion of financial negotiations with the DOE. The contract builds on a previous Phase I SBIR award in which SCI Engineered Materials successfully demonstrated that J_c performance could be increased with the addition of certain additives. Daniel Rooney, Chairman, President

and Chief Executive Officer commented, "We are pleased to receive this Phase II SBIR award. It reflects our demonstrated capabilities and ongoing interest in market applications for high temperature superconductor materials. This funded research draws upon SCI's core competencies and enables us to maintain and expand our technical capabilities".
Source: "
SCI Engineered Materials, Inc. Awarded Phase II Research Contract"
SCI Engineered Materials, Inc. press release (August 18, 2008)
http://www.sciengineeredmaterials.com/investors/ne/news/scia081808.htm

Magnet

Oxford Instruments (August 21, 2008)

Oxford Instruments (U.K.) has successfully operated a 22.07-Tesla, fully superconducting magnet at 4.2 K. The magnet is constructed from two HTS coils integrated into a 20-T, 78-mm wide bore LTS magnet. The 20-T LTS magnet is, in itself, an achievement as it is the first fully superconducting magnet with such a wide bore to be operated at 4.2 K. Within its wide bore, the LTS magnet can accommodate HTS insert coils to achieve a fully superconducting 25 to 30 T magnet system. The presently utilized HTS coils are 10-cm high concentric solenoids made from Bi-2212 round wire. The inner diameters of the coils are 20 and 55 mm, respectively. Meanwhile, the LTS magnet is made from NbTi and high-performance RRP^{TM} Nb_3Sn wires. Both LTS and HTS wires were developed and supplied by Oxford Superconducting Technology (OST), part of the Oxford Instruments Group. Importantly, by operating at 4.2 K, the superconducting magnets requires less liquid helium and can utilize a recondensing cooling solution, such as a mechanical cryocooler, to reduce helium consumption even further, compared with previous high-field, wide bore magnets that could only operate at 2.2 K. In addition, previous high-field magnets required large amounts of power and a specialized infrastructure to enable their operation, unlike the presently reported fully superconducting magnet.

The successful operation of this 22-T magnet also represents an important step forward in the IMPDAHMA project to develop an integrated modeling package for the design of advanced HTS magnet applications. The 22-T magnet will be used to measure the high fields of other HTS coils, providing data that is crucial to the development of the HTS modeling tool. The IMPDAHMA project is a three-year collaborative undertaking between Oxford Instruments NanoScience, Vector Fields Ltd. and the Institute of Cryogenics at Southampton University. The project is being partially funded by the U.K. Technology Strategy Board.
Source:
"Oxford Instruments achieves the first 22 Tesla at 4.2 Kelvin fully superconducting magnet using LTS and HTS materials"
Oxford Instruments press release (August 21, 2008)
http://www.oxford-instruments.com/wps/wcm/connect/Oxford+Instruments/Internet/Press/Current+News/Oxford+Instruments+achieves+the+first+22+Tesla+at+4.2+Kelvin+fully+superconducting+magnet+using+LTS+and+HTS+materials

Communication

Hypres Inc. (August 19, 2008)

Hypres Inc. has delivered two Digital-RF™ receiver systems to the U.S. Department of Defense's Office of Naval Research (ONR). The systems will be used as versatile test beds for evaluating Digital-RF technology for wireless communications applications, such as satellite and tactical communications, signals intelligence, electronic warfare, and software-defined radio. The systems include an additional temperature-controlled stage to permit the integration of high-temperature superconductor analog filters with the low-temperature digital electronics. Richard Hitt, CEO of Hypres, commented, "Delivering the test bed systems is an outstanding achievement for our entire team and a key milestone for Hypres. The systems can efficiently evaluate the chip design upgrades we develop when configuring our receivers for customers' specific operating parameters." The development of the two test bed systems was supported through an ONR Small Business Innovative Research (SBIR) Phase 3 contract valued at $650,000, with an exercised option of $75,000 to develop an improved analog-to-digital converter (ADC) chip.
Source:
"Hypres Delivers Two Digital-RF™ Receiver Systems To U.S. Office of Naval Research For Test and Evaluation Applications"
Hypres Inc. press release (August 19, 2008)
http://www.hypres.com/

Superconductor Technologies Inc. (August 12, 2008)

Superconductor Technologies Inc. has reported its financial results for the second quarter ending June 28, 2008. Total net revenues for the second quarter were $2.9 million, compared with $4.7 million for the same period in the previous fiscal year. Net commercial product revenues were $1.3 million, compared with $3.7 million for the same period in the previous fiscal year, and government and other contract revenue totaled $1.6 million, compared with $1.0 million for the same period in the previous fiscal year. Net loss for the second quarter was $3.3 million, compared with $2.0 million for the same period in the previous fiscal year. Jeff Quiram, STI's president and chief executive officer, said, "Our second quarter financial results are indicative of the shift in capital spending priorities in the first half of 2008, with the majority of our commercial customers focused on adding capacity to existing sites. We have made detailed preparations so that we can respond rapidly when our customers' spending priorities shift back to performance enhancement projects, a transition that we believe has already begun." As of June 28, 2008, STI had $13.0 million in cash and cash equivalents and a commercial product backlog of $12,000, compared with $143,000 at the end of the same quarter in the previous fiscal year.
Source:
"Superconductor Technologies Inc. Reports Second Quarter 2008 Results"
Superconductor Technologies Inc. press release (August 12, 2008)
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1186448&highlight

Accelerator

CERN (August 7, 2008)

CERN has announced that the first attempt to circulate a beam in the Large Hadron Collider (LHC) at the injection energy of 450 GeV (0.45 TeV) will be made on September 10. The announcement was made after the successful conclusion of the cool-down phase of the particle accelerator's lengthy commissioning process. The event will be televised through Eurovision and webcast through http://webcast.cern.ch. The LHC is the world's most powerful particle accelerator; once it reaches design

performance (probably by 2010), it will be capable of producing beams seven times more energetic and around 30 times more intense than any previous machine. At present, the commissioning of the LHC is proceeding with two synchronization tests to be performed over the next few weeks.
Source:
"CERN announces start-up date for LHC"
CERN press release (August 7, 2008)
http://press.web.cern.ch/press/PressReleases/Releases2008/PR06.08E.html

CERN (August 11, 2008)
CERN has provided an update regarding the commissioning of the Large Hadron Collider (LHC). The synchronization of the LHC's clockwise beam transfer system with the rest of the accelerator chain has been successfully achieved. During testing, a single bunch of a few particles were moved down the transfer line from the SPS accelerator to the LHC. After optimization, one bunch was kicked up from the transfer line into the LHC beam pipe and steered for about 3 km around the LHC itself. This test was repeated several times to optimize the transfer process. The counter-clockwise synchronization systems will be tested next.
Source:
"LHC synchronization test successful"
CERN press release (August 11, 2008)
http://lhc-first-beam.web.cern.ch/lhc-first-beam/News/LHCsyncTest.html

CERN (August 25, 2008)
CERN has announced that the second and final test of the Large Hadron Collider (LHC)'s beam synchronization system has been successfully completed. Similar to the previous test of the clockwise beam transfer system, the counter-clockwise was successfully completed on August 22. Lyn Evans, LHC Project Leader, commented, "Thanks to a fantastic team, both the clock-wise and counter-clockwise tests went without a hitch. We look forward to a resounding success when we make our first attempt to send a beam all the way around the LHC."
Source:
"Final LHC Synchronization Test a Success"
CERN press release (August 25, 2008)
http://lhc-first-beam.web.cern.ch/lhc-first-beam/News/FinalLHCsyncTest.html

Basic

University of California – Santa Barbara (August 5, 2008)
Researchers at the University of California – Santa Barbara have made what they are calling a milestone discovery in experimental quantum mechanics. The group used a superconducting electronic circuit known as a Josephson phase qubit to pump microwave photons one at a time and in a controlled manner into a superconducting microwave resonator. In this manner, the researchers were able to create photon number states, known as Fock states, in a controlled manner—something that has never been done before. Using the same technique, the researchers were also able to create another special state known as a coherent state. While these states are relatively easy to generate, they appear to behave in a completely non-quantum mechanical fashion; however, using the same analysis technique mentioned above, the researchers were able to demonstrate the expected underlying quantum behavior. Max Hofheinz, a postdoctoral researcher from Germany, explained, "The resonator is the electrical equivalent of a pendulum.

"n quantum mechanics, the energy, or amplitude of motion of this pendulum, only comes in finite steps, in quanta. We first carefully prepared the resonator in these quantum states and showed we could do this controllably and then measure the states. Then we 'kicked' the pendulum directly, a method where the amplitude can take on any value and appears to not be limited to these quanta. But when we look at the resonator with our qubit, we see that the amplitude does come in steps, but that the resonator is actually in several such states at the same time, so that on average it looks like it is not limited to the quantum states." The group's research could help in the quest to build a quantum computer. Their results were published in the July 17 issue of *Nature*.
Source:
"UCSB researchers make milestone discovery in quantum mechanics"
University of California – Santa Barbara press release (August 5, 2008)
http://www.ia.ucsb.edu/pa/display.aspx?pkey=1822

National Institute of Standards and Technology (August 6, 2008)

Researchers at JILA, a joint institute of the National Institute of Standards and Technology (NIST) and the University of Colorado at Boulder, have demonstrated a new photoemission spectroscopy technique for observing the properties of ultracold atomic gases. Whereas conventional photoemission spectroscopy probes the energy of electrons in a material, the new technique represents an adaptation that enables potassium atoms to be studied in ultracold gases. The group used the new technique to study superfluidity; specifically, they examined how atoms in a Fermi gas behave as they "cross over" from acting like a Bose Einstein condensate to behaving like pairs of separated electrons in a superconductor. In this crossover region, the atoms in an ultracold gas exert very strong forces on each other that mask their individual properties. By applying a radio frequency field to a cloud of trapped, paired potassium atoms, the researchers were able to eject a few atoms from the strongly interacting cloud and then turned off the laser trap. Subsequent measurements of the expanding gas were then used to calculate the atoms' original energy states and momentum values back when they were inside the gas. After mapping the energy levels for all the original states of the atoms, patterns showing the appearance of a large "energy gap" were identified. This energy gap represents the amount of energy needed to break apart a pair of the atoms. By enabling researchers to probe the energy and momentum of the particles simultaneously, the new technique represents a huge jump in the amount of information available to researchers studying ultracold gases. This research on superfluidity in atomic gases may eventually aid in the understanding of the energy gap that appears in high-temperature superconductors. The group's results were published in the August 7 issue of *Nature*.
Source:
"New JILA technique reveals hidden properties of ultracold atomic gases"
National Institute of Standards and Technology (August 6, 2008)
http://www.nist.gov/public_affairs/releases/ultracold_080608.html

Rice University (August 13, 2008)

Researchers from Rice University and Rutgers University have published a new theory explaining some of the complex electronic and magnetic properties of iron "pnictides", a new class of superconductors with relatively high transition temperatures. The new theory explains some of the similarities and differences between cuprates and pnictides. For example, the arrangement of atoms in both types of materials creates a "strongly correlated electron system" in which electrons interact in a coordinated way and behave collectively. The Rice and Rutgers researchers proposed that the pnictides exhibit a property called "magnetic frustration," a particular atomic arrangement that suppresses the natural tendency of iron atoms to magnetically order themselves in relation to each other. These frustration effects enhance magnetic quantum fluctuations, which may be responsible for the high-temperature superconductivity. Elihu Abrahams, a theorist at Rutgers University, added, "...even though we don't know the precise mechanism, we are still able to make some general predictions about the behavior of pnictides, and we've suggested a number of experiments that can test these predictions." The researchers' theory has been published in *Physical Review Letters*.

Source:
"New theory for latest high-temperature superconductors"
Rice University press release (August 13, 2008)
http://www.media.rice.edu/media/NewsBot.asp?MODE=VIEW&ID=11301&SnID=1162213282

Brookhaven National Laboratory (August 27, 2008)

Researchers at the U.S. Department of Energy's Brookhaven National Laboratory, in collaboration with Cornell University, Tokyo University, the University of California-Berkeley, and the University of Colorado, have reported the first experimental evidence explaining why attempts to increase the electrons' binding energy do not increase the transition temperature of high-temperature superconductors. The group's results show that as the electron-pair binding energy increases, the electrons' tendency to get caught in a quantum mechanical "traffic jam" overwhelms the interactions needed for the material to act as a superconductor. Understanding the detailed mechanism for how quantum traffic jams (technically referred to as "Mottness") impact superconductivity in cuprates may enable scientists to develop superconductors with higher transition temperatures.

High-temperature superconductors originate from non-metallic, Mott-insulating materials. Elevating these materials' pair-binding energy reduces the transition temperature closer to absolute zero, rather than increasing the transition temperature as it does in metallic superconductors. High-temperature superconductivity is thought to originate as a result of magnetic interactions between electrons, causing them to form superconducting Cooper pairs. The present group utilized "quasiparticle interference imaging" with a scanning tunneling microscope to study the electronic structure of a cuprate superconductor and found that the above-mentioned magnetic interactions get stronger even as electron holes are removed from the system. Thus, as the electron binding energy increases, the "Mottness" increases even more rapidly and reduces the ability of the supercurrent to flow. Lead author J.C. Seamus Davis elaborated, "In essence, the research shows that what is believed to be required to increase the superconductivity in these systems—stronger magnetic interactions—also pushes the system closer to the 'quantum traffic-jam' status, where lack of holes locks the electrons into positions from which they cannot move. It's like gassing up the cars and then jamming them all onto the highway at once. There's lots of energy, but no ability to go anywhere." The group plans to continue looking for solutions to this problem by searching for materials with strong electron pairing but that do not exhibit Mottness, including the new iron-based class of superconductors. The group's present research was published in the August 28, 2008, issue of *Nature*.

Source:
"Scientists reveal effects of quantum 'traffic jam' in high-temperature superconductors"
Brookhaven National Laboratory press release (August 27, 2008)
http://www.bnl.gov/bnlweb/pubaf/pr/PR_display.asp?prID=819

(Akihiko Tsutai, Director, International Affairs Division, ISTEC)
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Top of Superconductivity Web21

Fall, 2008 Date of Issue: October 8, 2008

Superconductivity Web21

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Feature Articles: Advances in Cryocooler Technology Development
- Needs Trend in Cryocooler Technology Development -

Yasuharu Kamioka, Corporate Officer, Deputy General Manager
Development and Engineering Division
Taiyo Nippon Sanso Corporation

Current developments in cryogenic cooling technology for high-temperature superconducting devices (HTS devices) are inadequate for commercialization purposes. However, the development of HTS devices is progressing, and there is only one more step toward the commercialization, which makes the development of new cryocoolers a pressing issue. Thus far, there are some cryocoolers, such as GM, Stirling, and pulse tube cryocoolers, as well as other systems such as gas turbine-type Brayton cycle cryocoolers, but there are still few cryocoolers that are suited to the HTS devices being commercialized, and most have been developed as cryopumps, cryocoolers for MRI systems, or cryocoolers for lab equipment. HTS devices require cryocoolers with improved form factors, size, temperature, cooling capacity, and efficiency among other things. Furthermore, it is impossible to use one type of cryocooler to cover the wide range of HTS devices, including transformers, motors, electric generators, current limiters, cables, equipment employing SQUIDs, mixers, and quantum computers. We need cryocooling systems compatible with each of these types of devices.

The temperatures that can be achieved with currently available cryocoolers range from 100 K to 3 K, which adequately covers the temperature range for cooling superconducting devices. With HTS devices cooled by comparatively small cryocoolers, either a direct cooling method where a GM cryocooler is used or a cooling method where a cryogen, such as liquid nitrogen, is placed inside and a cryocooler is used to cool it are applied. Consequently, in the commercialization of systems that can be cooled by such methods, improvements must be made so that the entire system will be accepted by society, and improvements in cost, reliability, stability, and ease-of-use are crucial. On the other hand, a look at their cooling capacity reveals a level of only 1 kW or less at 70 K for example. This is because there is no market for cryocoolers of 1 kW or more at 70 K and development is not underway due to compliance with the High Pressure Gas Control Law in Japan. Furthermore, developing GM, Stirling, and pulse tube cryocoolers of several kW is technologically difficult, due to such problems as thermal exchange inside the cryocoolers. However, greater cryocooling capacity is required for HTS devices, including transformers, cables, and motors. Meanwhile, for devices of 30 kW or more at 100 K, there is a cold air separation plant that uses an expansion turbine, and although it is not a cryocooler per se, it can be manufactured as one. A conceivable candidate for cryocooler with a cooling capacity from several kW to 10 kW at temperatures between 40 and 65 K is a small Brayton cycle cryocooler (gas turbine-type cryocooler). Fig. 1 shows the performance of currently available cryocoolers and the cooling capacity required by HTS devices, such as transformers, cables, and motors. We can see that there are not currently any cryocoolers with the necessary cooling capacity for transformers, cables, and motors, and that there is a need for developing cryocoolers of that size.

Development of high-temperature superconducting materials has continued over the past 20 years, and we are now near the point of commercializing devices that employ superconductivity. But commercialization requires a dramatic breakthrough in technology development. Amid the fast pace of recent science and technological advances, there are fears that there may end up being no place for high-temperature superconductivity due to advances in existing technologies, just as what happened with the Josephson computer. We should commercialize and release the best devices possible with current technology now

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instead of waiting for a technology that is 100% perfect.

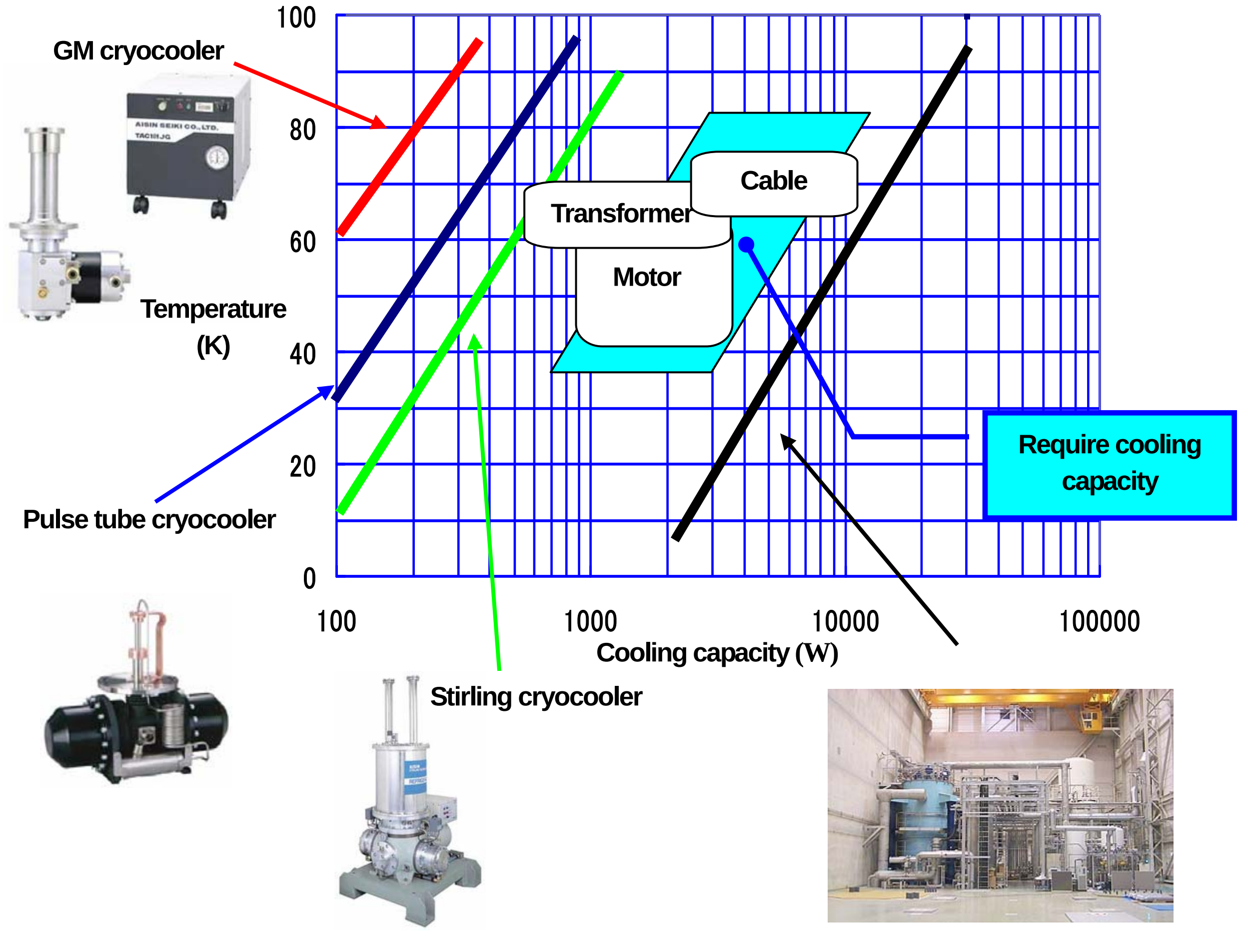

Fig. 1 Performance of currently available cryocoolers and cooling capacity required by HTS devices

Source:
Initial issue, Low-Temperature Journal 2007 vol. 1, Cryogenic Association of Japan

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Top of Superconductivity Web21

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Feature Articles: Advances in Cryocooler Technology Development
- Development of Small Gas Turbine-Type Cryocooler -

Yasuharu Kamioka, Corporate Officer, Deputy General Manager
Development and Engineering Division
Taiyo Nippon Sanso Corporation

Cryocoolers on the level of 2 to 10 kW at 70 K are required for cooling such HTS devices as transformers, cables, and motors. At that level, GM and Stirling cryocoolers are too small to be useful. Turbine-type Brayton cycle cryocoolers are a conceivable candidate, but from the standpoint of the manufacturing technology for turbines, they are too compact and have many difficulties. However, since they satisfy the necessary cooling capacity, this method is believed to be the only choice. Within the NEDO-sponsored project that was carried out from 2006 to 2007, ISTEC and Taiyo Nippon Sanso Corporation developed a compact turbine-type Brayton cycle cryocooler that used neon gas as its working fluid. Fig. 1 shows the flowchart of a cooling system containing the cryocooler we developed. Figure 2 is a photo of the cryocooler cold box.

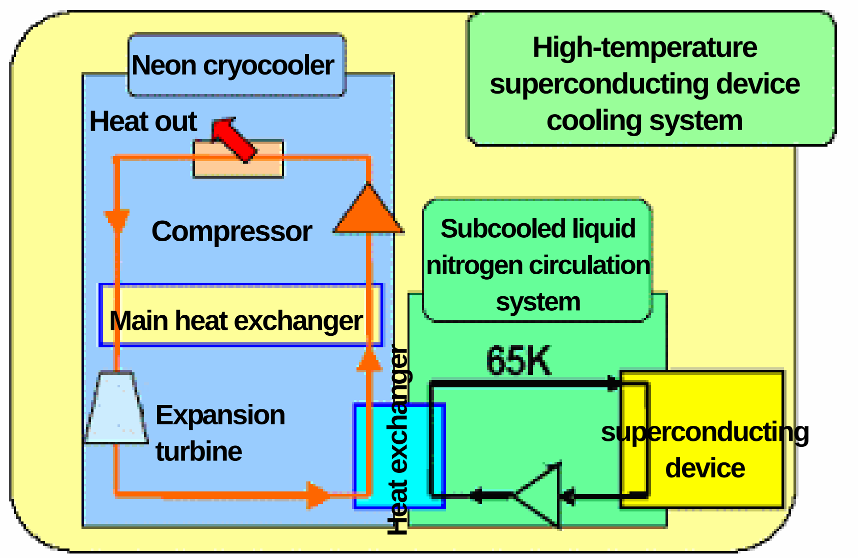

Fig. 1 Cryocooler flowchart

Fig. 2 Cold Box

The cryocooler we developed cools liquid nitrogen that is circulated by a subcooled liquid nitrogen circulation system, and the cooled liquid nitrogen is used to cool superconducting devices. As shown in Table 1, the cryocooler itself delivers a cooling power of 2 kW at 65 K. The table also shows the design and actual values.

In developing the cryocooler, existing technology was used to the absolute limit, and a small expansion turbine (22 mm diameter) and a plate-fin heat exchanger were employed. The development of a compressor was left for a future project. Instead, a commercially available compressor was used, so size and efficiency were not optimized. We believe the development of a compressor is crucial to commercialization.

The resulting cryocooler was small for a turbine-type model and delivered 2 kW at 65 K thanks to its ability to adequately exploit the performance of the small turbine by using neon, which has a high molecular

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weight. This was the world's first small turbine-type cryocooler to use neon as its working fluid. The turbine operated at its design value of 100,000 RPM. As a result, you might say that the way has been opened for providing for the first time anywhere in the world cryocoolers suited to cooling high-temperature superconducting devices. A turbine is a maintenance-free device, and currently commercialized turbine-type cryocoolers are either models that use air turbines, which process a large flow of air or models that use helium. However, both are large and have a cooling capacity of several tens to several hundreds of kW, and the development of cryocoolers with a cooling capacity of several kW is desired. It is difficult to improve performance with smaller turbines, and with cryocoolers of 2 kW or more, it is possible to easily design and manufacture models using technology currently available.

Table 1 Cryocooler design values and actual values

			Design value	Actual value (1)	Actual value (2)
①	Pressure on high-pressure end	MPa	1.9	1.91	1.9
②	Pressure on low-pressure end	MPa	0.9	0.86	0.86
	Flow	Nm3/hr	1200	1132	1151
③	ET RPM	rpm	96000	95820	95520
④	Cooling capacity	kW	2	2.75	2.03
⑤	Set temperature	K	70	69.9	64.9
⑥	Power used	kW	50	57	57
	Cooling efficiency	COP	0.04	0.047	0.035

We plan on optimizing the heat exchanger and design a turbo compressor in a bid to develop compact yet durable cryocoolers for superconducting devices, and if this project moves forward, it should end up enabling the commercialization of high-temperature superconducting devices that are currently under development as next-generation eco-friendly devices and promoting their entry onto the market in a major way.

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Top of Superconductivity Web21

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Feature Articles: Advances in Cryocooler Technology Development
- Developing a 20 K Oil-Free 2-Stage Cryocooler -

Tsutomu Tamada
Superconductivity Team, Electric Power R&D Center
Chubu Electric Power Co., Inc.

Chubu Electric Power Co., Inc. and Aisin Seiki Co., Ltd. have developed a Stirling-type 20 K oil-free 2-stage cryocooler with cooling capacity of 100 W and continuous operating time of 20,000 hours or more.

Stirling cryocoolers are mainly used in small cooling capacity applications, such as cryopumps, but a cooling capacity of 20 K 100 W or more is necessary for superconducting magnetic energy storage systems, and high-volume cryocoolers that are easy to maintain are required.

Conventional cryocoolers after continuous operation, hydrogen and hydrocarbons that origin is thermal decomposited lubricating oil (contaminating gases) has been confirmed. As a result, these gases accumulate and solidify in the regenerator, thereby hampering heat exchange and decrease cooling performance. In response, the following improvements have been made to resolve this situation.

Main improvements
1) Built in a composite filter for absorbing contaminating gases.
2) Built a sealing section for the wear-prone pistons so that they could withstand 20,000 hours of operation.

Table 1 Specs of 20 K oil-free 2-stage cryocooler

Items	Specs
Cooling capacity (@20 K)	100 W or more
Power consumption	16 kW or less
Voltage/frequency	AC 200 V 60 Hz
Operating frequency	6 Hz
Required cooling water (30 ºC or less)	1.0 m^3/h or more
Dimensions	1.2 x 1.1 m x 1.5 m (W x L x H)
Weight	Approx. 1,300 kg

The above-mentioned improvements were optimized for the cryocooling structure and enabled the development of a cryocooler with a cooling capacity of 100 W or more at 20 K.

The latest cryocooler developed is durable and can be used ~~in~~ for high-capacity applications, such as superconducting magnetic energy storage systems, which means decreases costs can be expected for cryocoolers thanks to expanded applications for cry coolers.

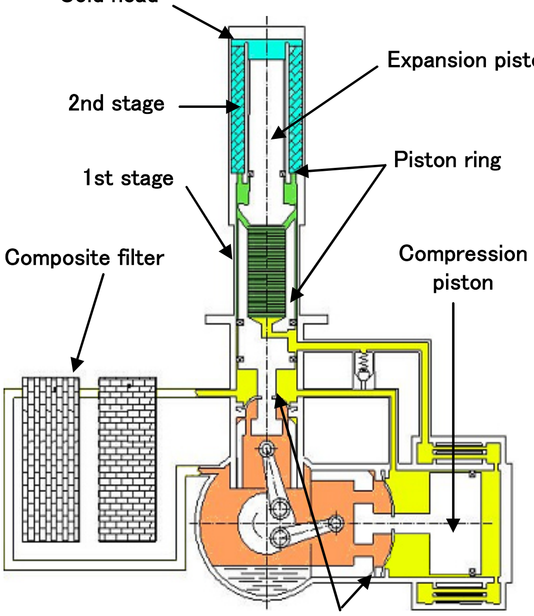

Fig. 1 20 K oil-free 2-stage cry cooler

Note that this development project was jointly handled by Chubu Electric Power Co., Inc., Kyushu Electric Power Co., Inc., and the International Superconductivity Technology Center under the auspices of NEDO as part of the power technology program of the Agency for Natural Resources and Energy, Ministry of Economy, Trade and Industry. The project was conducted over a four-year term starting in 2004.

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Top of Superconductivity Web21

Fall, 2008 Date of Issue: October 8, 2008

Superconductivity Web21

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Feature Articles: Advances in Cryocooler Technology Development
- R&D on an Ultra-Low Vibration Pulse Tube Cryocooler -

Yuki Ikushima
Engineering Department, Precision Equipment Division, Solutions Group
Sumitomo Heavy Industries, Ltd.

A cryocooler is a type of refrigeration device that can cool a substance to a cryogenic temperature. The 4 K GM cryocooler shown in Fig. 1 has a cooling capacity of about 1 W at the temperature of liquid helium, and it is widely used in low-temperature equipment that requires a temperature of 4 K (Kelvins), including MRI and NMR systems using superconducting magnets. Cryocoolers make it easy to handle cryogenic temperatures, but one of their drawbacks is their high vibration level. The introduction of cryocoolers into highly sensitive analysis equipment is often considered, so users are increasing demanding low-vibration models.

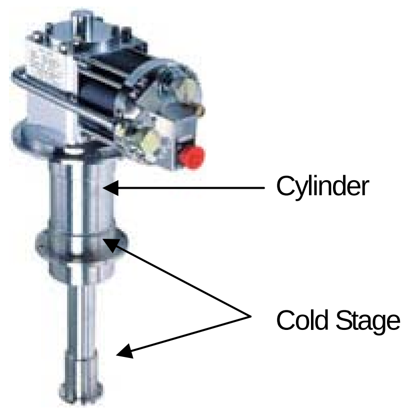

Fig.1 GM cryocooler
(cold head section)

Fig. 2 Pulse tube cryocooler
(cold head section)

A typical vibration source of cryocooler is the mechanical motion of solid parts. In a GM cryocooler, a solid moving part known as a displacer is in the cylinder section and vibrations due its reciprocating motion transmit vibrational acceleration to the cryostat. In recent years, pulse tube cryocoolers (Fig. 2) have been commercialized as a solution to the vibration problem. Since pulse tube cryocoolers have no solid moving parts in the cooling section, they can reduce vibration acceleration transmitted to the cryostat compared with a GM cryocooler. However, there is still a problem of vibration amplitude of about several tens of μm in the cold stage of pulse tube cryocoolers. This is due to the elastic deformation of the pulse tube that comes with a change in pressure (expansion and compression) of about 1.0 MPa or more. Vibration can be reduced by raising rigidity, such as making the pulse tube's walls thicker, but since this invites an increase in heat infiltration, it is not a fundamental solution.

Sumitomo Heavy Industries, Ltd. has jointly developed with the High Energy Accelerator Research Organization an ultra-low vibration cryocooler that uses a pulse tube refrigeration device for a gravitational wave detector. Extremely sensitive distortion measurement is required for gravitational wave detectors. The decision was made to use a cryocooler to eliminate thermal noise, which led to improved sensitivity in the laser interferometer. However, since the cryocooler must not have a vibrational impact on the detector, its specifications were designed to have submicron vibration amplitude and a cooling capacity of 0.5 W at 4.5 K.

This development project introduced a new vibration reduction scheme that was an improvement over conventional schemes. Fig. 3 shows a conceptual diagram of the ultra-low vibration cryocooler. Its features are as follows:

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1) Introduction of a new cold interface (VR stage)
2) Valve unit separation
3) Introduction of a bellows tube between the cold head supporting flange and the cryostat

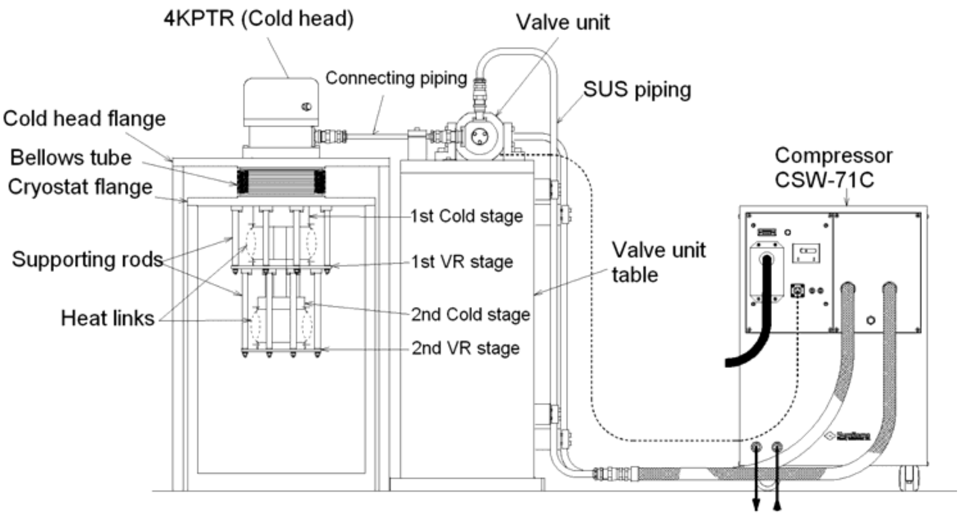

Fig.3 Overview of ultra-low vibration cryocooler

We measured vibration amplitude and cooling capacity for the completed ultra-low vibration cryocooler. Table 1 shows the measurement results. Our cryocooler succeeded in lowering vibration amplitude in the pulse tube axial direction by three figures, and even in all direction including the lateral direction of the pulse tube, we confirmed submicron vibration amplitude. As for cooling capacity, our cryocooler achieved 0.5 W at 4.5 K, which shows that it can satisfy values required for a gravitational wave detector. As far as we know, there had been no 4 K pulse cryocooler that has achieved submicron vibration amplitude until this ultra-low vibration cryocooler, and our cryocooler would have the lowest level of vibrational performance in the world.

Table 1 Measurement results of ultra-low vibration cryocooler

Cooling capacity	2nd level VR stage (0.5 W)		4.34 K
	1st level VR stage (20 W)		50.5 K
Vibrational amplitude	2nd level VR stage	x	±0.61 μm
		y	±0.73 μm
		z	±0.05 μm

Ten of these low-vibration cryocoolers, both 4 K and 80 K models, were installed on a laser interferometer that serves as a prototype gravitational wave detector, and they have been operating smoothly for over a year. The same vibration reduction scheme is also starting to be used on systems for measuring low-temperature properties and other instruments.

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Top of Superconductivity Web21

Fall, 2008 Date of Issue: October 8, 2008

Superconductivity Web21

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Feature Articles: Advances in Cryocooler Technology Development
- Developing a High-Capacity (1 kW) Pulse Tube Cryocooler -

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Railway Technical Research Institute

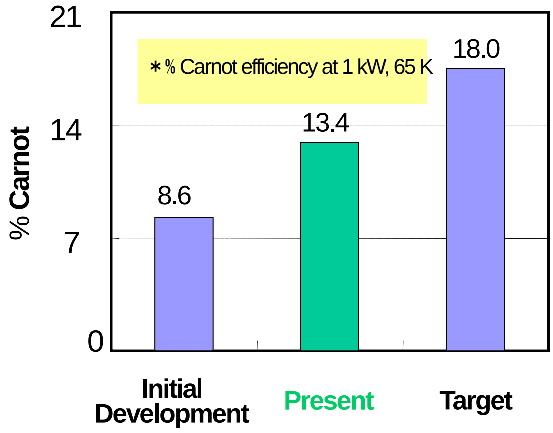
Development has begun on a high-capacity pulse tube cryocooler as a cooling system for a superconducting traction transformer that supports a trolley voltage of 25 kV on the Shinkansen. The required specifications of the cryocooler are a cooling performance at 65 K at 1 kW or more and a percent Carnot efficiency of 18% or more (T_h = 300 K). A development issue in satisfying the required specifications is the weight reduction of Shinkansen vehicles. The goal is to promote weight reduction by using superconducting coils in the traction transformer, which is the heaviest piece of equipment mounted on rail a vehicle. The oil-cooled non-superconducting traction transformers currently mounted on N700 series Shinkansen cars have a weight-to-capacity ratio of 0.69, and as of April 2008, they are the lightest weight traction transformers in existence. If this weight-to-capacity ratio can be further lowered, the merits of converting to superconducting coils can be demonstrated.

Example of commercial pulse tube cryocooler for a traction transformer

In designing a superconducting traction transformer, after examining a weight of an iron core and the current capacity of superconducting wires, when a capacity of 4-MVA is assumed and the AC loss is 1 kW or less, the aim is a weight-to-capacity ratio superior to a non-superconducting transformer, even when the weight of a subcooled liquid nitrogen cooling system is added. Therefore development of a small high-capacity cryocooler is required.

The reason for selecting a GM type pulse tube cryocooler is the belief that system reusability will be easy based on the fact that on a natural circulation cooling system that contacts the pin pole type heat exchanger at the cold head of the GM cryocooler, absorption of small-scale head loads has been verified. Furthermore, the lightening of cryocooler weight can also be expected because there is no displacer.

The performance of the prototype pulse-tube cryocooler using an active buffer in phase control was a cooling capacity of 1.19 kW at a temperature of 65 K, and the percent Carnot efficiency was 8.6%. For the on-off valves between the compressor and cryocooler



Change in Carnot efficiency

and between the cryocooler and active buffer, instead of special rotary valves, multiple solenoid valves were connected in parallel to evaluate and test performance.

After further improvements, including changing the regenerator material configuration mesh, improving the gas conductance on the above-mentioned line (enhance the Cv value of the solenoid valves and increase the number of solenoid valves), and adding a manifold buffer tank to the compressor's compound line, percent Carnot efficiency was raised to approximately 13.4% without lowering cooling capacity. Optimizing special rotary valve design through these efforts made it possible to fulfill the required specifications.

Reference: http://www.rtri.or.jp/rd/openpublic/rd77/CS/cs_1.5.html

In addition, other high-temperature superconducting devices, such as superconducting cable systems and superconducting current-limiting device, also require cryocoolers with the aforementioned specifications, and we hope that through aggressive competition between various labs and research institutes, R&D will be conducted on cryocoolers with even better performance.

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Top of Superconductivity Web21

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Feature Articles: Advances in Cryocooler Technology Development
- R&D on Thermoacoustic Coolers -

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Department of Mechanical Systems and Design
Graduate School of Engineering, Tohoku University

It was thought that sound waves conveyed through a gas were adiabatic, which meant the process could not be used to achieve a cooling effect. However, with recent advances in thermoacoustic research, the generation of low temperatures using sound waves is now not all that difficult. The key is to use sound waves within a narrow channel. Sounds waves in such channels do not expand/contract adiabatically. Rather, there is good heat exchange between the sound waves and the solid wall that forms the channel. Thermoacoustic cooling is one of the many thermoacoustic phenomena resulting from heat exchange between channel walls and sound waves. Thermoacoustic cooling can be quite easily achieved with simple tools as discussed hereafter.

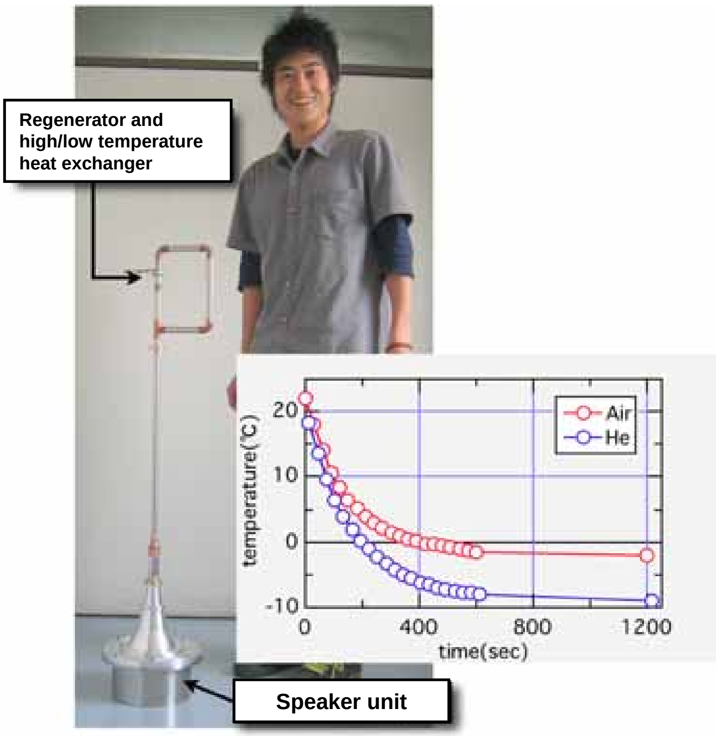

Fig. 1 Traveling-wave thermoacoustic cooler and its cooling temperature

A narrow tube consisting of a laminated metal mesh (often called a regenerator) is fitted into a hollow tube so that it sandwiched by a pair of heat exchangers. After the tube is filled with a suitable gas, heat is transported in the regenerator's axial direction simply by using a sound source, such a speaker, to produce sound waves at one end of the tube. The temperature (T_C) of one heat exchangers lowers, while the temperature (T_H) of the other heat exchanger rises. Fig. 1 shows the traveling-wave thermoacoustic cooler created for demonstration purposes by a fourth-year student at our research lab. The outer diameter of the tube is 16 mm and the entire system is 1.2 m long. It uses a woofer speaker as its sound source for generating sound waves of the fundamental frequency of the air column within the tube. While using cooling water to keep T_H at room temperature, we plotted the measurement results for T_C on a graph. When the gas filled into the tube was air, a low temperature of -2 °C was achieved, and when it was replaced with helium, a low temperature of -10 °C was achieved

Using the thermoacoustic phenomenon, it is possible to create thermoacoustic engines in addition to acoustic wave cooling. Heating one portion of an air column tube until the thermal gradient exceeds a certain critical value causes the air column to start vibrating at a characteristic frequency, thereby functioning as a thermoacoustic engine. While a normal engine makes a solid piston vibrate, a thermoacoustic engine makes a column of air vibrate, to produce output power in the form of sound waves . Thermoacoustic cooling using sound waves spontaneously generated through heating makes it possible to produce low temperatures without any moving parts. A group at the Los Alamos National Laboratory is in the midst of a natural gas liquification project using this sort of cooling system.[1)] In addition, a group in China is achieving temperatures below 70 K by combining a thermoacoustic engine with a pulse tube cryocooler.[2)] New devices using intratubular sound waves are also being proposed one after the other in Japan, and a patent search turns up a dramatic increase in such devices as we entered the 21 century.

Devices that exchange/transport energy using vibrational motion (sound waves) in a fluid that accompanies pressure oscillation includes pulse tube cryocoolers, regenerative cryocoolers, such as the Gifford-McMahon refrigerator, Stirling engines, and dream pipes. However, the thermoacoustic theory proposed by Tominaga universally disputes these devices.[3)] In thermoacoustic theory, the heat flow, work flow, and entropy flow occurring due to vibrational motion constitute central physical concepts, and one of the crucial parameters that influences the size of these flows is phase difference Φ between the pressure oscillation and velocity oscillation in the fluid. As a result of our ability to measure work flow and phase difference Φ by simultaneously measure pressure and velocity[4)] or using the two-sensor technique,[5), 6)] our experimental understanding of thermoacoustic phenomena is deepening.[7)] It has recently been pointed out that it is even possible to markedly raise efficiency at the temperature levels from room temperature to near the temperature of liquid nitrogen in conventional pulse tube cryocoolers by focusing on the energy flow.[8)] There are high hopes for advances in thermoacoustic coolers that can employed in high-temperature superconducting applications.

References and Sources:

1) http://www.lanl.gov/projects/thermoacoustics/index.html
2) W. Dai *et al*., A heat-driven thermoacoustic cooler capable of reaching liquid nitrogen temperature, Applied Physiscs Letters 86, 224103 (2005).
3) Akira Tominaga, "Fundamentals of Thermoacoustics," Uchida Rokakuho Publishing Co., Ltd.
4) T. Yazaki, and A. Tominaga: Proc.R. Soc. Lond.A 454, 2113 (1998).
5) A. M. Fusco, W. C. Ward, and G. W. Swift: J. Acoust. Soc. Am. 91, 2229 (1992).
6) T. Biwa, Y. Tashiro, H. Nomura, Y. Ueda, T. Yazaki: Rev. Sci. Inst., 78, 086110 (2007).
7) e.c. T. Biwa Y. Tashiro M. Ishigaki Y. Ueda, T. Yazaki: J. Appl. Phys., 101, 064914 (2007).
8) Yuki Ueda, Chisachi Kato, "Series B, Journal of the Japan Society of Mechanical Engineers," pp. 727, 839 (2007); Yuki Ueda, Tetsushi Biwa, "Cryogenics," pp. 41, 73 (2006).

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends
- Forum on Superconductivity Technology Trends 2008 -

Shoji Tanaka, Honorary Director General, delivering the keynote address

ISTEC held the Forum on Superconductivity Technology Trends 2008 on Monday, May 19 at the Toshi Center Hotel, Tokyo. Some 200 representatives from the Japanese government, corporations, academia, mass media, and the general public participated in the forum, where research results, challenging issues, and trends in superconductivity development for industrialization were reported and heated discussions took place.

Ryoji Doi, Director, Research and Development Division, Industrial Science and Technology Policy and Environment Bureau, Ministry of Economy, Trade and Industry, and Hideki Fukuda, Director General, New Energy Technology Development Department, New Energy and Industrial Technology Development Organization (NEDO) delivered congratulatory messages. They stated that the superconductivity development project has already continued for 20 years and is now progressing toward the next step, and they pointed out how important it is by stating that no other projects have continued for so long. They also mentioned that superconductivity is a crucial technology that is positioned as one of the innovative technologies for realizing Cool Earth 50, and that they also saw it as a key technology for solving environmental problems and had high hopes for its commercialization.

In his keynote address entitled "Superconductivity Research: Yesterday, Today, and Tomorrow," Shoji Tanaka, Honorary Director General, Superconductivity Research Laboratory (SRL) stated that new technologies with extremely broad universal applicability, such as thermomotors will be required in solving the many difficult questions currently surfacing in regards to the global environment. Recent research advances are believed to have brought us one step closer to room temperature superconducting, and this has further stimulated researchers' efforts.

In a presentation entitled "Developing High Performance Materials for Y-based Wires and Evaluation Technology," Keiichi Tanabe, Director, Advanced Materials & Physics Division and Electronic Devices Division, SRL proposed Ba-poor material, introduced the importance of achieving high J_c within a magnetic field by developing an inside plume technique, and reported that his division was contributing to accelerated development by feeding back data to wire development.

In a presentation entitled "Device Applications and Material Development for Bulk Superconductors,"

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Izumi Hirabayashi, Director, Bulk Superconductor Laboratory, Advanced Materials & Physics Division, SRL reviewed the advances being made in developing materials for superconducting bulks and recent technological development trends, and reported on the potential for expanding their applications to various devices.

In a presentation entitled "Developing Bulk Superconducting Magnets for Small NMR Systems," Yoshitaka Ito, Imura Material R & D reported on technological developments for small NMR systems that make the most of the magnetic field homogeneity at the center of circular bulk superconductors. He also stated that there are hopes for a wide-range of applications by means of device miniaturization.

In a presentation entitled "Applications for Superconducting Devices in Communications Devices," Mutsuo Hidaka, Director, Low Temperature Superconducting Device Division, Electronic Devices Division, SRL/ISTEC introduced superconducting technology that will solve the issues that are of concern in the future of telecommunications. He reported on superconducting SFQ switches that will solve the problem of rising power consumption, superconducting AD converters that will compensate for the lack of processing speed of semiconductor circuits, and superconducting single-photon detectors (SSPD) for quantum communication that will solve security issues.

In a presentation entitled "Electrification Technology for Microwave Superconducting Filters," Kazunori Yamanaka, Fujitsu Laboratories Ltd. provided an introduction into the development of multistage filters for power transmission that exploit that characteristics of high-temperature superconductivity in order to effectively utilize limited radio frequencies.

In a presentation entitled "The Current State and Future of Y-based Wire and Equipment Elemental Technology Development," Yuh Shiohara, Deputy Director General, SRL and Director, Superconducting Tapes & Wires Division reported on the latest progress being made in developing high-performance long wires, low-cost long wires, and extremely low-cost wires by the NEDO's Project and the efforts being made in leading research and development on equipment applications. He also reported on the hopes for the development of technology for Y-based superconducting power equipment as a next-stage project.

In a presentation entitled "Developing Superconducting Current Limiters Using Y-Based Wire," Takashi Yazawa, Toshiba Corporation provided an introduction into a current limiting coil made of high-resistance NiCr stabilized Y-based wire and a 6.6 kV three-phase current limiter system that used it. He also introduced the results of current limiting tests.

In a presentation entitled "Development and Outlook of Expansion Turbine Cryocoolers for High-Temperature Superconducting Devices," Yasuharu Kamioka, Taiyo Nippon Sanso Corporation introduced the current state of development work on a new expansion turbine cryocooler that reduces the size of their existing model in order to achieve the cooling capacity, small size, and long life required for commercializing superconducting devices.

In a presentation entitled "Current State and Future of Superconducting Power Network Control Technology (SMES)," Shigeo Nagaya of Chubu Electric Power Co. Inc. reviewed the development details of the NEDO SMES project, reported on the verification of both the economic efficiency and performance of SMES system technology through an actual interconnection test, and provided an introduction into the deployment of SMES coil technology into other applications based on those results.

Finally, in a wrap-up address entitled "State and Trends in R&D on Superconducting Application Equipment in Various Countries," Osami Tsukamoto, Professor Emeritus, Yokohama National University introduced the status of superconducting cables, current limiters, and transformers that are being actively developed in the U.S., Europe, China, Korea, and other nations based on the outlook for the lengthening and commercialization of Y-based wire. He advocated that Japan also actively pursue superconducting equipment commercialization.

The forum served to remind us of the significance and importance of further collaboration between industry, academia, and government in this milestone year where a new step is being made toward commercialization based on the steadily increasing results being produced by research and development in various superconducting fields.

Forum participants

(Masaharu Saeki, Director, Research & Planning Department, ISTEC)

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends
- Superconductivity Yesterday, Today, and Tomorrow -

Shoji Tanaka's address

At last year's forum, the impact of the BRIC nations was debated, but this year it was reported that the area known as MENA (Middle East and North Africa) was experiencing dramatic growth. Global energy, resource, water, and food shortages are forecast, and according to a report by the UN ICPP, the Earth's temperature will rise 2 ºC by 2030 due to increasing levels of CO_2 and other greenhouse gases.

A similar situation occurred at the end of the 18th century. The people at the time feared an explosive grown in population and food shortages. Malthus published "An Essay on the Principle of Population" in which he came to a conclusion known as the Malthus Trap, which ultimately states, "The power of population is indefinitely greater than the power in the earth to produce subsistence for man." Fortunately, Watt perfected the steam engine, a type of heat engine, in 1765, and this combined with the sudden rise of a variety of industries, advanced humankind and forged the foundation of the British Empire, thereby avoiding the Malthus Trap.

In the 20 century, quantum mechanics was declared complete and irrevocable in 1927, advances in microphysics launched the semiconductor industry, and nuclear physics led to the birth of the nuclear power industry with the discovery of nuclear decay and is now opening the way for a transition from fast breeder reactors to nuclear fusion. And at present, advances are being made in superconducting technology, which is a macroscopic quantum phenomenon, and the development of quantum computing is underway.

The second phase of the Collaborative Research and Development of Fundamental Technologies for Superconductivity Applications project successfully concluded, and applications of the superconducting wire that was developed to all manner of electrical equipment is expected. However, the emergence of room temperature superconductivity is likely needed before we will see universal applications, such as the heat engine.

1. Superconductivity Yesterday

All high-temperature superconductivity includes the two dimensional CuO_2 plane, and this is wherein superconducting phenomenon occurs. The questions at the time were, "Are there any factors that can be passed onto future material development? And considering our experience thus far, can we predict the structure of new superconducting materials?"

1) All the starting materials are insulators.

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2) Massive doping is required (1 % to 10 % or more)

3) Crystal structures due to doping are invariable.

4) Since the two-dimensional plane is included, crystal structures are two-dimensional.

5) From the above standpoint, would new materials more likely to be ionic bonded materials than covalent bonded?

6) Why is the two-dimensional plane necessary?

2. Superconductivity Today

Recent advances

1) Tests on the Nemst effect continue to shed light on the pseudogap, and the actual state of phase transition is coming to light. Pairing occurs simultaneously with a pseudogap, and this can be interpreted as superconductivity not occurring due to phase fluctuation. If this true, then pairing occurs at 250 K and we have taken one step closer to room temperature superconducting.
2) The material recently discovered by Hosono at the Tokyo Institute of Technology includes a two-dimensional layers comprised of iron and arsenic, and since it has a T_c exceeding 45 K, it is a deeply intriguing material.

3. Superconductivity Tomorrow

There are now a host of difficult questions concerning the Earth, and the very future of humankind is of grave concern. The answer to all such questions lies in developing widely applicable new technology that has the great universality of the steam engine in the 18 century, and we believe that room temperature superconducting just might be the steam engine of the 21 century.

I wish my fellow researchers around the world great success in their efforts.

(Shoji Tanaka, Honorary Director General, SRL/ISTEC)

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends - Advances in Fundamental Superconductivity Technology -

In a presentation entitled "Development of High Performance Materials for Y-based Wires and Evaluation Technology," I introduced the results of development work on advanced materials and long wire evaluation technology, which the Advanced Materials & Physics Divison led in NEDO's project "R&D of Fundamental Technologies for Superconductor Application, Phase 2", which wrapped up in March this year. Since cuprate superconductor materials have large anisotropy, improving the irreversibility field, that is, the maximum magnetic field in which superconducting current can flow is a key issue in wire material development for equipments used in high magnetic fields, such as SMES and motors. In the project, we proposed various methods, including those for controlling the carrier concentration of Y-based wires, selecting rare earth element Gd, and employing Ba-deficient thin-film composition, which improved critical current density J_c in a magnetic field. These methods are actually employed in the manufacture of long wires as well. We also proposed the inside plume technique, which places a substrate inside a laser plume and forms a film when manufacturing superconducting thin film using the PLD method. Adjusting the target composition not only enables a three to five-fold boost in the rate of film formation, it also achieves critical current I_c exceeding 100 A, even in a 3 T magnetic field parallel to the c axis, at 77 K in a short wire where artificial pinning centers were introduced. Meanwhile, nondestructive evaluation of I_c and macroscopic defect distribution is mandatory in applications of long Y-based wires to power equipments. Thus far, we have developed evaluation systems based on direct current injection, Hall sensors, or magnetooptics, but recently we used a SQUID magnetic sensor to develop a system that detects with great sensitivity eddy current turbulence that is induced within manufactured multi-filamentary wires that were cooled to the superconducting state. This sensor is capable of the high-speed evaluation of macroscopic defects in the multifilamentary wire used in AC equipments. By developing and using a new high-temperature superconducting SQUID 5 channel gradiometer array that uses oxide film layering technology at the Electronic Devices Division, we demonstrated that it is possible to detect the location of macroscopic defects in five filaments of 5-mm wide wire at a speed of 30 m/hour.

In a presentation entitled "Device Applications and Material Development for Bulk Superconductors," Izumi Hirabayashi, Director, Bulk Superconductor Laboratory, introduced recent technological advances toward the application of bulk superconductors to devices. Bulk superconductors are approaching a J_c of 1 MA/cm^2 at 65 K and 4 T thanks to the optimization of composition and the introduction of pinning centers, and large bulk materials with a diameter of 150 mm have been manufactured. In the development of a superconducting magnetic bearing using bulk superconducting materials, uniform rotation symmetry was achieved by forming and arranging the bulk materials in order to reduce rotational loss caused by the placement of separate superconducting bulks. For the pulse field magnetization necessary in applications, a magnetization record of 5.2 T was set at Iwate University by temperature and field pulse contrivances, and at Tokyo University of Marine Science and Technology, a two-layer coil was developed for magnetizing large bulk materials. In addition, in a recent study of applications to a high-intensity x-ray system undulator, a magnetization method by electromagnetic induction was developed using a ring-shaped bulk superconductor and a permanent magnet array, and magnetization permanence exceeding several tens of thousand times was proven in material reinforced by vacuum impregnation. In addition to lowering materials cost, securing high efficiency magnetization technology, developing cooling technologies, and ensuring safety are issues in the future of the bulk materials business.

The presentation by Yoshitaka Ito, Senior Researcher, Imura Material R&D introduced the recent results

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of superconducting bulk magnet development (a portion of which was consigned by NEDO) that was aimed at small NMR and conducted jointly with JEOL Ltd., Riken, and ISTEC. NMR systems are progressing along two lines. On one hand, there are large systems for high-resolution structural analysis that use frequencies of 1 GHz or more by applying a powerful magnetic field, and on the other hand, there are small general-purpose systems of 400 MHz or less. The use of superconducting bulk materials cooled by a pulse cryocooler instead of the superconducting coils that are traditionally used results in a smaller leakage field, and as a result, we can expect the development of super-small, easy-to-maintain, NMR systems. Meanwhile, achieving a uniform magnetic field space is the key to the application of bulk materials. Circular bulk material, which has good magnetic uniformity, was considered, and a magnetization method within a uniform field of 4.7 T by means of a superconducting magnet was used. The design of a bulk material size for securing a uniform magnetic field space 3 mm in diameter and 5 mm long within a tube was performed through a magnetic field distribution simulation. With Gd materials for which manufacturing technology has advanced, uniformity is difficult due to the large influence of the paramagnetic moment and the disorder of the applied magnetic field. A method that sandwiches Gd bulk material by Sm bulk material with a low paramagnetic moment and 70 mm thick Eu bulk materials were developed to solve this problem. As a result, performance satisfying the required specifications for NMR magnets was demonstrated, including a magnetic field uniformity of 0.5 ppm or less in a detection area with a diameter of 1 mm and a length of 5 mm and a magnetic field stability of 0.78 Hz/h.

(Keiichi Tanabe, Director, Electronic Devices Division, and Advanced Materials & Physics division, SRL/ISTEC)

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends
- Applications for Superconducting Devices in Communications Devices -

Information communications of the future are expected to implement all manner of functions and transcend mere infrastructure, developing into a social system that binds people together, as typified by the ubiquitous network, which means communications anytime, anywhere, and with anyone. To achieve this, the communication networks crisscrossing the globe must grow explosively in terms of both transmission speed and capacity. The ubiquitous network will mean a massive increase in the amount of information that must processed on the communication devices at the network branches known as nodes, and it has been noted that there are several problems that existing technology cannot solve alone.

The most serious of these problems is the growing power consumption of network devices. Forecasts place the power consumption of the electronic communications industry in 2015 as high as 33 times that of 2004, and as a result communications-related business are adopting energy saving measures. The problems pointed out in 2000 by former Director General of the Superconductivity Research Laboratory (SRL) Shoji Tanaka have now come to pass. In particular, routers, which are devices that switch packet destinations according to addresses are forecast to grow even larger in the future, and even now there are monster machines (Cisco's CRS-1) with a power consumption reaching 1.3 MW. By using ultra fast, low-power circuits known as single flux quantum (SFQ) circuits, we could lower the power consumption of routers that have a processing capacity equivalent to such monster routers to 1/30 the currently level, including the power used by cryocoolers. At SRL, we have implemented the portion of a router known as the switch, which requires the fastest processing of all its components, using SFQ circuits, and are successfully transmitting video data over a LAN comprised of this SFQ switch along with four PCs.

There are also fears that semiconductor technology alone cannot solve the need for greater processing performance. This is typified by AD converters, which convert a signal from analog to digital. Two types of superconducting AD converters featuring high precision and high speed are being developed. Both make it easy to increase performance because they operate with a simpler structure than semiconductor AD converters by means of the unique properties of superconducting circuits. The high speed of SFQ circuits also contribute to improved performance.

There are hopes that superconducting single photon detectors (SSPD) will serve as detectors for implementing quantum communications that promises absolute security because it is absolutely impossible to wiretap without leaving any traces. It is believed that low-noise, high-speed SSPDs are optimal for the detection of the single photons used in quantum communications. A quantum encryption key distribution test over a distance of 100 km is already underway, and quantum communications are expected to be commercialized within five years.

Applying superconducting devices to the right places in communications devices can solve the problems that were impossible with conventional technology, and this is expected to lead to a future with a more rich communication environment.

(Mutsuo Hidaka, Director, Low Temperature Superconducting Device Division, SRL/ISTEC)

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends - Current status and Future Prospects of Coated Conductors and Power Application elemental Technology Development -

Y-based high-temperature superconducting wire (so-called coated conductors) is a multilayer structure consisting of oxide intermediate layers, a superconducting layer (YBCO), and stabilizing layers in that order on a metal substrate, such as Hastelloy^{TM}. Development of such wire is in progress with the major themes of attaining higher performance and cost reduction for future commercialization as superconducting electric power devices using the coated conductors (C.C.). R&D for application of the c.c.s is also underway on making coils, cables etc. and preliminary production of elemental devices such as cables and motors using this wire. The development of the coated conductors as well as the elemental electric power device technology is being pursued as a national project in Japan.

Development of high performance wire

High-performance wires with a uniform and high I_c properties have been developed by using Hastelloy^{TM} as a substrate, forming oxide intermediate layers with biaxially-grain alignment by means of ion beam assisted deposition (IBAD), and then forming a cap layer and superconducting layers by means of pulsed laser deposition (PLD). In 2005, a wire with an I_c x L (wire length) value of 52,000 Am was successfully fabricated (a world record at that time), and a process was further developed for improving characteristics by replacing all or a portion of the Y in the YBCO superconducting layer with other RE elements, such as Gd or Sm. In addition, a microstructure with nano BZO rods (known as a bamboo structure) was obtained in the superconducting layer by adding zirconia, and confirmed by cross-sectioned TEM observation. It is now clear that the BCO nano-rods drastically improved the characteristics under applied magnetic fields as flux pinning centers. This technology was transferred to Fujikura Ltd. where it led to the manufacture of high-performance long wires that had a world-record-breaking 503.5 m-349.6 A/cm-w in spring of 2008.

Low cost wire

Adopting processes that use inexpensive production systems, such as a non-vacuum process, and increasing process speeds are investigated as a mean for reducing the technology cost of C.C. Reduction of the wire cost is performed by applying the metal-organic deposition (MOD) method, which is a non-vacuum process to deposit the superconducting layers, and increasing the IBAD process rates for intermediate layer which is the largest factor in increasing costs in the conventional methods. The following success was reported; improving the starting solution for the MOD process and development of the multi-turn process, including optimization of the MOD solution composition and improvement of its thermal decomposition behavior of the organics in the solution, resulting in fabrication of 250 m-310 A/cm-w@77 K, s. f. wire at a low cost by transferring these technologies to SWCC. ISTEC also succeeded in improving the magnetic field angular dependence of the I_c characteristic by introducing artificial pinning centers both in PLD and MOD processes. The IBAD process was also improved by adopting MgO as a IBAD material which could be grown with biaxial texturing about 100 times faster than the conventional GZO, thereby enabling a drastic improvement in its production rate and a reduction in cost as well. Using the new IBAD process, ISTEC succeeded in the fabrication of 41 m-353 A/cm-w@77 K, s. f. and 5 m-260 A/cm-w@77 K, s. f. wires by further film deposition of the superconducting layer on the IBAD layer by the PLD and MOD methods, respectively. In addition, 50 m-208 A/cm-w@77 K, s. f. wire was obtained by SWCC, even in an extremely low cost coated conductor by the MOD process using an textured metal substrate that was comparatively inexpensive.

ISTEC also developed post-processing technologies, including those for wire cutting, multi-filamentallization and insulation covering, so that these wires could be used for superconducting electric power devices. We also fabricated a prototype 20 m cables and coils, and conducted an over current test and confirmed reduced AC losses and current-limiting operation as well.

Future prospects

A project for developing superconducting electric power devices using Y-system coated conductor has started in June this year. SMES (Superconducting Magnetic Energy Storage), power cable and transformer are the main targets for development in this project and the C.Cs. will be further developed and being satisfied for the requirements of the respective devices.

Acknowledgement

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(Yuh Shiohara, Acting Director General, Deputy Director General, Concurrent Division Director Division of Superconducting Tapes & Wires, SRL/ISTEC)

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends
- Developing a Superconducting Current Limiter Using ReBCO Wire -

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Power and Industrial Systems R&D Center
Toshiba Corporation

Between 2006 and 2007, we developed fundamental technology for superconducting current limiters in the Ministry of Economy, Trade and Industry's Applied Basic Technology project. Our aim was to evaluate the applicability of next-generation conductors developed in the project to Co., Ltd. the fault current limiters..

In this project, we used Hastelloy® substrate-based YBCO wire and GdBCO wire that were processed by the IBAD/PLD method. We used NiCr as a stabilized metal layer to keep high resistance. Using these wires, we manufactured three phase set of coils with the capacity of 72Arms, in which the wires were wound in parallel around bobbins to possess less self-inductance. These coils were then inserted into a single sub-cooling liquid nitrogen vessel, thereby achieving an operating temperature of 70 K. Fig. 1 is a photo of the three-phase coils secured to a suspension device and a photo of a cryocooling vessel and cryocooler compressor. This was later combined with peripheral equipment to integrate a 6.6 kV current limiter system. The peripheral equipment consisted of circuit breakers, voltage/current meter (VT, CT), and a sequence system. The necessary components were housed within a cublicle. Fig. 2 is a photo of the current limiter panel we developed. The entire panel is divided into a cryostat-panel housing the superconducting equipment, a circuit breaker panel, and a incoming panel from right to left.

Fig. 1 Three-phase current limiting coils (left),Subcooling liquid nitrogen vessel and cryocooler compressor (right)

Fig. 2 Current limiter panel (consists of a receiving panel, circuit breaker panel, and a cryopanel)

Table 1 is a list of the main tests we carried out on the 6.6 kV three-phase limiter.

Before installing the coils into the vessel, they were each individually tested for current-carrying performance as DC and AC perfromances. At the point we housed the coils in the vessel and at the point we configured them into the panel, we confirmed insulation voltage of AC 22 kVrms between the coils and ground and between the coils themselves for one minute, which is the withstand voltage specification for the 6.6 kV apparatus. Next, we combined the three-phase superconducting current limiter with a short-circuit generator and then conducted a current limiting test simulating a three-line ground fault. The temperature environment was 70K at 100 kPA . The current limiter successfully suppressed the 1,560 A fault current to 840 A (54 %) at the first wave. The current waveforms obtained in the test were in good agreement with simulation results. We also carried out a two-phase ground fault test in addition to the three-phase test, and thereby confirmed a good current limiting effect in response to the application of 6.6 kV as well as the functioning of the designated sequence operation. Finally, we installed the 6.6 kV three-phase current limiter system in a utility field at Tokyo Gas Co., Ltd., conducted an interconnection verification test that had the system continuously running with a gas engine power generator connected with the electric power system, and confirmed the soundness of the system.

Table 1 List of main tests conducted on 6.6 kV three-phase limiter

Test item	Result
Current-carrying performance of coils of each phase	• ±2 % current distribution between wires at 72 Arms rating • AC loss: Approx. 3.5 W/phase
Withstand voltage performance	• Between RST-ground: 22 kVrms x 1 min. • Between phases: 22 kVrms x 1 min.
Current limit test	• 3-phase ground fault: 6.6 kVrms current limit • 2-phase ground fault: 6.6 kVrms current limit
System connection test	• Autonomous operation: 6.6 kVrms/66 Arms • Interconnected operation: 6.6 kVrms/72 Arms

Using an IBAD/PLD Hastelloy® substrate YBCO wire and GdBCO wire with high resistance, we developed coils for current limiter, and after ultimately building a 6.6 kV three-phase limiter, we conducted verification tests, including a current limit test and interconnection test. This R&D project enabled us to demonstrate applicability to current limiters using next-generation wire and to obtain knowledge toward the commercialization of superconducting current limiters.

Acknowledgements

This project was undertaken through a commission from the New Energy and Industrial Technology Development Organization (NEDO), as part of the Ministry of Economy, Trade and Industry's Applied Basic Project. Furthermore, this was a joint project between with ISTEC, Yokohama National University, and Fujikura Ltd. The interconnection test also included Tokyo Gas Co., Ltd..

Note: Hastelloy® is a registered trademark of Haynes International, Inc.

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends - Current State and Future of Superconducting Magnetic Energy Storage (SMES) Technology -

Shigeo Nagaya, Leader
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There are high hopes for SMES in electric power applications due to its rapid responsiveness, durability in the face of large-scale charging/discharging, and high output to storage capacity. SMES was once considered for use in hourly load leveling that is an alternative to pumped-storage power plants, but recently commercialization of so called micro-SMES is being planned for application in compensating for the instantaneous drop in voltage measured in seconds that occurs during a lightning strike or similar event. In the U.S., SMES systems from 1,000 to 3,000 kW have been commercialized, and in Japan, a 10,000 kW system is in operation.

This article briefly introduces the background of SMES development thus far and provides a simple overview of the technology.

Since superconducting technology can handle large amounts of electricity compactly thanks to its high current density characteristic and dramatically lower electrical loss, it has wide ranging applications to electric power, including generation, transmission/transforming, and storage. Development of electric power equipment using conventional metal superconductors has also started, amid the superconducting fever sparked by the discovery of oxide superconductors, and full-fledged SMES development has been launched as a national project of the Agency for Natural Resources and Energy in response to a feasibility study started in 1991 that included model tests at various power companies.

Is SMES technological feasible for the objective of this develop project, i.e., building a pilot plant? And what about its system control ability? Studies on these questions are underway, and they have already proved that SMES is technologically feasible and that it can independently control active/reactive power and has high control/response properties.

However, several problems and issues have come to light, particularly the fact that the cost is a huge barrier to commercialization. Because of the high performance of superconducting technology, people are apt to demand versatile functionality, and since this is possible, there are conductor and coil configurations capable of responding to any application. This results in a system where only conductors that are force-cooled, have a seventh-stranded structure to limit AC loss, and a current rating of 20 kA are the only kind created. System cost is thus 4million yen/kW and the conductors developed are 14 yen/Am.

In response, we put our efforts behind calculating the life cycle costs of target items and developing cost-lowering technology for those targets, specifically how we were going to lower the cost of superconducting coils, which were the biggest piece of the cost puzzle, and if were able to lower the cost, was the cost-benefit of SMES functionality going to hold up in the face of competing or alternative technologies? Over a five-year period starting in 1999, we proceeded with the development of coils, which are the main part of SMES and a major cost factor, by optimizing specifications and configurations in accordance with system usage in an effort to cut cost and paring down the SMES targets to system stabilization and load change fluctuation/frequency regulation.

Our specific cost lowering measures consists of evaluating conductor, coil, and system design, as well as their manufacture and operation and the tolerances of each part and each stage. Based on the necessary functionality and performance required for SMES applications, we made revisions, studied optimization techniques, produced and evaluated a prototype model coil, and then verified the adequacy and reliability of those techniques.

To compensate for load fluctuation, wherein there is continual and repeated charging/discharging, we composited a good conductor, such as aluminum or copper, from the strand stage to ensure current carrying stability up to that point, but then by simultaneously co-stranding a copper wire with a superconducting wire at the conductor creation stage, we were able to omit the compositing process and the configuration became simpler, which thereby achieved stability beyond the design and delivered a conductor that could be used under steeper current fluctuations and more powerful magnetic fields than anticipated. Since SMES stores energy as magnetic fields in the coil, there are installation space constraints when taking into account field leakage, but we solved this practical problem by combining four coils and developing an arrangement (multipole system) that inverts the poles of neighboring coils. And in the case of SMES, increased electrical current, a feature of superconducting, is actually a major cost-boosting factor from the cost standpoint of the system side, including transformers. The conductors and coils developed this time have a current rating of 10 kA, but by employing high stabilization, high current density became possible for the conductors and high energy density became possible for the coils. Based on such development results, we believe a load change compensated SMES, which was initially estimated to cost 80 billion yen, could be configured for about 1/6 to 1/7 of that amount (about 12 billion yen). Therefore, we see SMES being possible at a cost less than 70,000 yen/kW for system stabilization applications and 200,000 yen/kW for load change compensation applications in the life cycle calculated based on SMES cost-benefit.

The 10,000 kW instantaneously compensating SMES mentioned at the beginning of this article can now be realized for the first time by applying the results of our technology for reducing coil cost.

Systemization development was conducted toward demonstrating system control ability, which was a lingering issue, from the cost aspect outlook. This development work was for the latest superconducting power network control technology, and it targeted interconnection with an actual electric power system towards early commercialization and evaluated SMES as system control equipment.

Unlike electric power devices such as cables and transformers, the performance of SMES is decided by the system configuration. In particular, the configuration of AC/DC converters, which interconnect with the system and input/output electric power, impact not only system performance, but also the performance necessary for the superconducting coils. On the other hand, converters are combined technology, and performance and costs change dramatically based on configuration considerations. In light of the circuit configuration, current-type converters are applied to SMES, which is a current source, but most of the power sources that require converters at present are voltage sources, and that is why voltage-type converters are in wide use. When employing a voltage-type converter for an SMES power source, it must be combined with a chopper and condenser in addition to an inverter, and thus component members, such as semiconductor elements increase, but general-purpose technology can be applied and we can expect the quantity effect to kick in. In developing the latest demonstration system, we did not focus solely on a current-type system, but instead reconsidered it from the standpoint of cost and technological trends as well as from the converter system verification in the interconnection test performed in the last half of the project. Our target is a conversion efficiency of 98 % or more while keeping costs low, and we studied a configuration in which 20,000 yen/kW per output actually used was technologically feasible. As a result, voltage-type converters that employ large amounts of semiconductor elements can achieve balanced configuration in terms of performance, cost, reliability, and extendibility. Also, depending on the coil configuration, the multicell method that combines coils and converters on a 1:1 basis and integrated output on the converter side can achieve a higher degree of freedom in future yttrium-based SMES. In addition to this, we succeeded in developing elemental technology essential to SMES systemization, including a nearly maintenance-free, highly reliable, highly efficient cryocooler and current leads with a high electrical resistance performance of 15 kV or more.

Using a specially selected converter system and 20 MJ coil that we were able to manufacture through our SMES develop project thus far, we verified two system stabilization modes. One was load change compensation that requires repeated charging/discharging characteristics, which is a feature of SMES, and the other was stabilization operation for when some sort of fault occurs on the system. These two tests were conducted with the cooperation of Nikko Plant, the Furukawa Electric Co., Ltd., and targeted load compensation for the fluctuating load at a metal rolling mill, and a stabilization test for the Furukawa Nikko Power Generation's hydroelectric power generating plant that supplies power to the Nikko Plant was also conducted.

There were time constraints in the testing of fluctuating load compensation operation, but we were able to verify and prove the disturbance restraint effect of SMES for 50,000 or more charges/discharges, which greatly exceeded the initial target of 20,000, by conducting load shutdown tests on a hydroelectric generator.

This project proved that the capability of SMES as power control equipment was beyond what was initially expected. It is believed that SMES is more feasible than ever before thanks to the superior field properties of yttrium next-generation wire, which has at last demonstrated rapid technological advances in terms of commercialization, and its most useful high mechanical strength for SMES coils.

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Top of Superconductivity Web21

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Feature Articles: Forum on Superconductivity Technology Trends - State and Trends in R&D on Superconducting Application Equipment in Various Countries (Electric Power Equipment) -

Osami Tsukamoto, Professor Emeritus
Graduate School of Engineering
Yokohama National University

The use of high-temperature superconducting (HTS) in electric power systems is believed to be the most promising and largest-scale of all HTS applications. The application of superconducting technology enables equipment to be dramatically reduced in size and weight and improved in terms of efficiency and performance. And since it also enables the creation of equipment with new functionality that was never before possible, it transforms power systems into systems that are even more reliable and flexible. Electric power systems, which are growing ever more complex and massive, are faced with a variety of issues, including site and environment problems, and forecasts hold that in the near future, it will become increasingly more difficult to resolve such issues by extending conventional technologies. Hopes are, therefore, pinned on superconducting technology as a useful solution for these issues. To that end, development work is strategically and aggressively underway on superconducting equipment in nations worldwide.

The Forum covered the worldwide development state of major electric power equipment, mainly superconducting cables, current limiters, and transformers.

There are currently twelve projects total (including those in the planning stages) targeting superconducting cables exceeding 30 m underway in Japan, the U.S., Korea, and China. Almost all of them are performing tests by actually connecting superconducting cables to an electric power system. Development work is particularly flourishing in the U.S., which accounts for half of all the projects, specifically, three currently underway and three in the planning stages. The longest cable for which a current conducting test has been completed had been a 500 m cable developed in Japan, but just recently in a project in Long Island, U.S., they succeeded in conducting current over 600 m cable, making it the longest so far. If a project currently being planned in the U.S. succeeds in developing a cable, they plan on incorporating it into an electric power system and then commence operation. At present, most long cables use Bi-silver sheathed wire, but Japan and the U.S. are developing cables using Y-based wire in an effort to further lower AC loss, and in the U.S., they are conducting actual system tests where they connect Y-based wire cables to Bi wire cables. In this manner, there is a steady advance toward the commercialization of superconducting cables.

Current limiters that employ superconductivity have functionality for autonomously limiting short-circuit current from the first wave, and they can interconnect between electric power systems without increasing short-circuit current. Because of this, they can increase the degree of freedom in designing electric power systems and they are expected to dramatically ease the constraints on the amount of new power sources, such as distributed power sources, being introduced. Development aimed at system deployment is currently underway in Japan, the U.S., China, Korea, and Germany, and development at the elemental technology level is also underway in such countries as Italy, UK, and Israel. This shows the great interest there is in developing such technology in many different nations. Along side superconducting cables, current limiters are believed to be superconducting devices nearest to commercialization. A variety of superconducting current limiting methods have been considered, but super-to-normal transition type limiters using thin film wires are becoming the mainstream in the power distribution system. It is thought that iron

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core saturation type limiters are suited to higher voltage levels for electric power systems, and development aimed at system deployment tests is currently underway in the U.S. and China.

The development of superconducting transformers formally flourished in Japan, the U.S., and various European countries, but the number of countries undertaking such efforts is in decline. China developed and tested a three-phase transformer that used Bi wire, but a similar development project that had been underway in the U.S. is currently on hold. Japan is aiming to further lower AC loss on transformers by making coils that use Y-based wire that segments the superconducting layer and then demonstrating a dramatic reduction in AC loss. Development efforts in Japan are flourishing, including the development of a light-weight, compact, and highly efficient transformer using Bi wire so that it can be mounted on a Shinkansen (bullet train) car.

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Top of Superconductivity Web21

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Feature Articles: Trends in SQUID and Medical Diagnostic Technologies - Expansion of High Temperature Superconducting SQUIDs into Long Superconducting Tape Conductor Evaluation Technology -

In recent years, the development of high-temperature superconducting (HTS) wire that uses Y-based cuprate superconductor material, or the so-called second-generation (2 G) wire, has been actively underway through national projects in many countries, including Japan, the U.S., and various nations in Europe and Asia. In Japan, NEDO's project "R&D of Fundamental Technology for Superconductor Application (Phase 2) " (2003-2007) developed a 500 m long wire with a critical current I_c of 300 A (77 k per 1 cm width and within a self-magnetic field) or more. And in June, NEDO launched a new project aimed at developing elemental technology for commercializing, deploying, and spreading superconducting power equipments, namely SMES, cables, and transformers, by around 2020.

Y-based wire is manufactured by growing an intermediate layer comprised of an insulator in which the crystallographic axis has been made uniform on an approximately 100 µm thick metal tape substrate and then growing in an epitaxial manner a superconducting layer that is about 2 µm thick. And to suppress breakdown and thermal instability when shifting to normal conductivity, a stabilization layer of Ag or Cu about 10 to 20 µm thick is formed on the very top to create a multilayered structure.

Reducing AC loss is a major issue in the application of superconducting wire to cables and transformers, and striation or segmentation processing is required for reducing this loss. For instances, demonstrations with a small model coil are showing that AC loss decreases in inverse proportion to the number of divisions. This coil was made by a special winding method and wires that were scribed into a metal substrate by using a laser, as shown in Fig. 1.

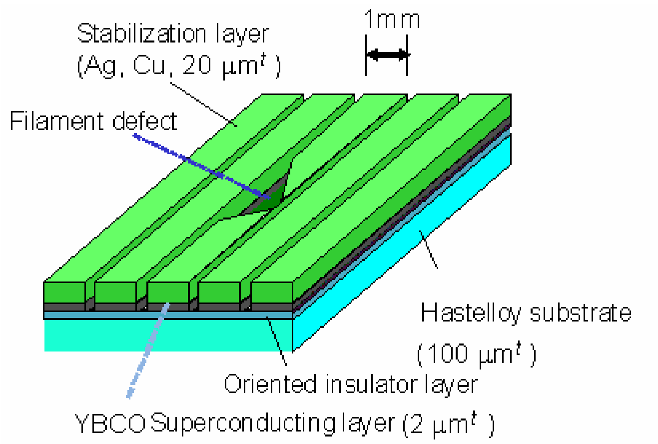

Fig. 1 Y-based wire that has undergone striation processing
(Technology for evaluating filament defects is required)

On the other hand, practical-level transformers require several tens of kilometers of 300 m or longer wires that have been striated into around 0.5 to 1 mm wide filaments, but supplying such wires requires not only the development of stable processing technology in which no deterioration of wire properties occurs, but also the development of technology for making wire properties uniform across both the wire's length and width. For instance, when there is a micro-region with low I_c due to a defect or other problem with the superconducting layer, there is almost no problem with a 1 cm-wide wire, but after striation processing, filaments with extremely low I_c may result. If there were technology for rapidly evaluating such defective areas, we could expect a dramatic rise in long processed wire yields because we could not only feed back results into wire manufacturing technology and processing technology, but also apply appropriate fixes to low I_c sites.

Hopes are pinned on the application SQUIDs, which are basically magnetic sensors with super-high sensitivity, to not only medical uses such as in magnetoencephalographs and magnetocardiographs, but also mineral exploration and nondestructive testing. In particular, easily cooled HTS SQUIDs have been studied thus far for application in the nondestructive testing of a variety of products, including the internal cracks in aircraft wheels and the inspection of microholes in narrow copper tubes. There is also a report of a study that targeted nondestructive testing of break sites in Cu-clad Nb-Ti wire. Such testing is conducted by using a coil to apply an AC magnetic field to the specimen and then using a SQUID sensor (gradiometer) with differential detection coils to detect minute variations in the magnetic field that is produced by internally induced eddy currents that circumvent the defect site. There are two major issues when we try to apply this method to striation processed wires. The first is the multichannelization of sensors in accordance with the number of segments, or in other words, the improvement of spatial resolution, and the second is how well we can extract information on the superconducting layer located under the Ag stabilization layer, which is thick and through which electric current easily flows.

Using oxide thin film layering technology and ramp-edge Josephson junction manufacturing technology that were accumulated during the development of HTS single flux quantum (SFQ) devices thus far, the Superconductivity Research Laboratory (SRL) has developed a 5-channel array gradiometer sensor (Fig. 2) that can support the testing of wires with five 1 mm-wide filaments. Unlike conventional HTS SQUIDs, this sensor has superior array property uniformity along with no weak coupling between grain boundaries whatsoever, and therefore, it operate in a stable manner even in an AC field. As shown in Figure 3, SRL also developed a system that cools a Y-based tape wire to T_c or colder by running it reel-to-reel through a cryocooler and uses a SQUID to carry out detection. Since a large shielding current flows over the superconducting layer in the superconducting state, it can detect defects with a high degree of sensitivity.

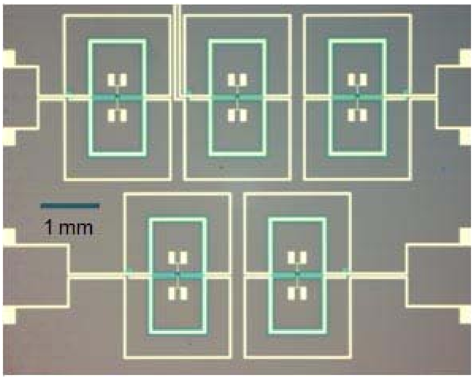

Fig. 2 5-Channel array-type SQUID gradiometer sensor

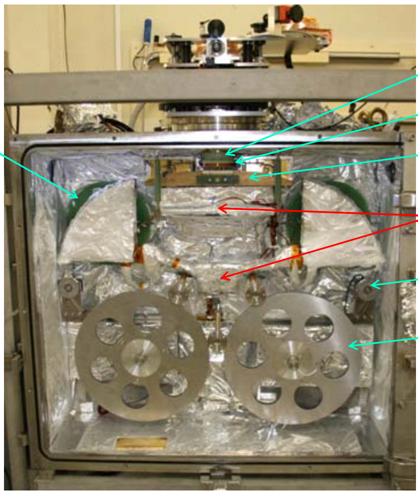

Fig. 3 Reel-to-reel long wire evaluation system using a SQUID

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Fig. 4 is an example of the evaluation results obtained after applying an AC field equivalent to 100 µT at 3 KHz to a 5-segment wire that is 25 m long. The peak indicated by the arrow is the signal corresponding to a region where I_c was locally low. In addition, numerous small signals can be observed. This is believed to be an indication of sites with insufficient scribe treatment, which results in shorts between adjacent filaments. Current testing speed is limited to about 30 m/h at the cooling efficiency of the wire, but 100 m/h, a speed adequate for the evaluation of practical long wires, can be expected through improvements in cooling efficiency. Moving forward we plan on manufacturing a prototype array sensor with an even smaller detection coil and then establishing it as evaluation technology for commercial-level Y-based long wire by shedding light on the correspondence between SQUID signals and defect types and the degree of I_c degradation.

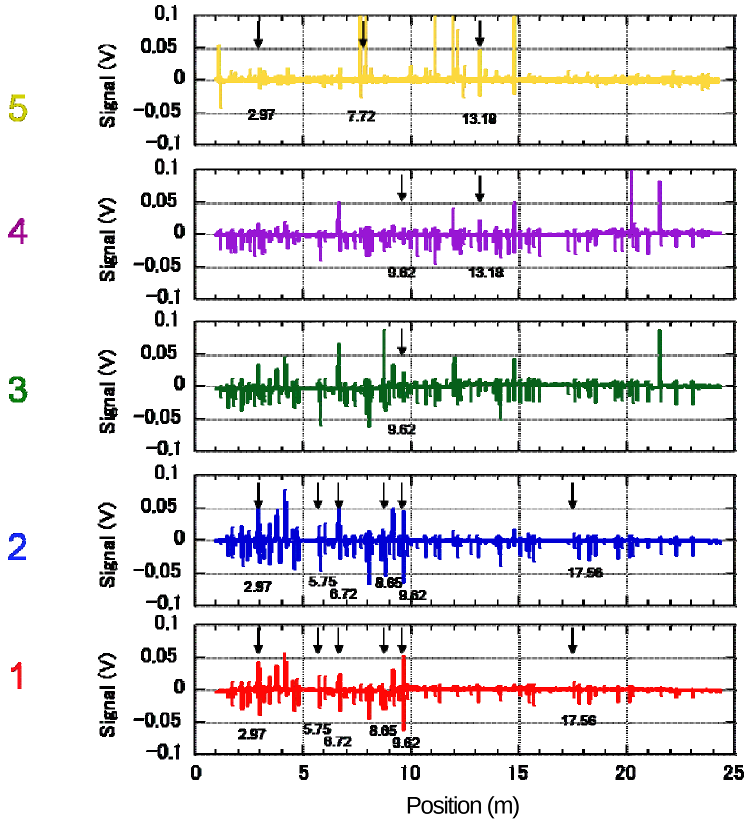

Fig. 4 Example of evaluating a striation processed wire
(Signals of 5-channel sensor when evaluating a 25 m long wire)

(Keiichi Tanabe, Director, Division of Electronic Devices and Division of Materials Science & Physics, SRL/ISTEC)

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Top of Superconductivity Web21

Fall, 2008 Date of Issue: October 8, 2008

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Feature Articles: Trends in SQUID and Medical Diagnostic Technologies - Diagnostic Technology for Railway Rails Using SQUIDs -

Yoshiki Miyazaki
Cryogenic Systems, Maglev Systems Technology Division
Railway Technical Research Institute

A hardened layer known as a white etching layer may occur on parts of the surface of rails where railcar wheels contact them. Rail damage known as shelling or minute cracks may be observed around the white etching layer, and this is believed to lead to peeling on the rail's top surface or the fracture of the entire rail itself. http://www.rtri.or.jp/rd/openpublic/rd45/kouzou/research08/index.html

Measurements and visual inspections of white etching layers are currently underway on a spot-check basis, but there is no way to perform continuous inspections. However, if we could get continuously distributed information on such white etching layers, it would provide an effective basis for studying the relationship between the line information and the occurrence of white etching layers.

In this research, conducted jointly with Prof. Hideo Itozaki, Osaka University, a nondestructive detection technique using a superconducting quantum interference device (SQUID) is studied as the means of detecting white etching layers.

The basic principle behind the measurements is the same as with eddy-current defect testing. However, when using a SQUID to measure a magnetic body such as a rail, the body's residual magnetization becomes large DC magnetization noise, which has an impact on SQUID operation. We, therefore, combine the SQUID with a noise compensating circuit or other means for canceling geomagnetism and residual magnetization, in order to enable the effective measurement of rails. Fig. 1 shows a rail that was measured. The top surface of the rail was coated with the etchant Nital to expose the white etching layer to the naked eye. Fig. 2 shows the measurement results.

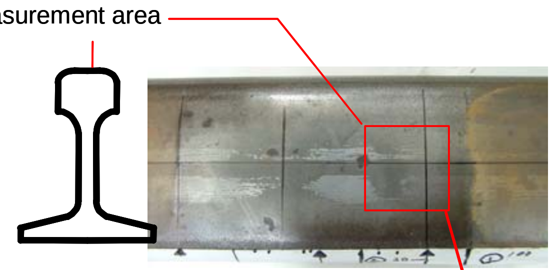

Fig. 1 Sample of top surface of rail
(image after application of etchant)

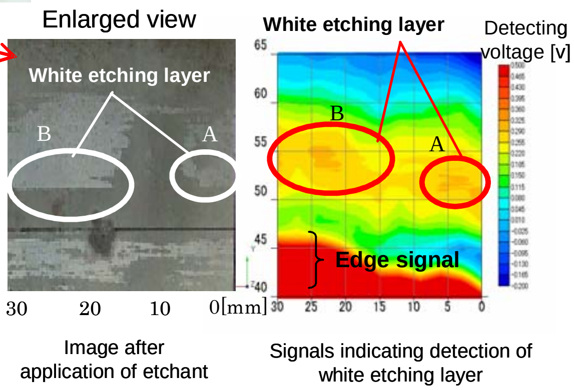

Fig. 2 Measurement sites and detection signals

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Superconductivity Web21

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The consistency between the white etching layer at sites A and B and the strong signals A and B in Fig. 2 is good, which means there is a close correspondence between the white etching layer and the measurement signals. The signal variation is thought to indicate the detection of physical variations (permeability and resistivity) due to structural changes (pearlite to martensite) in the white etching layer, and we discovered that it was possible to detect the white etching layer with a SQUID. Moving forward, we plan on developing a measuring system that can detect white etching layers in the field.

http://www.rtri.or.jp/rd/openpublic/rd77/CS/cs_1.7.html

We believe that the early detection of white etching layers by such a technology will enable even more efficient rail management.

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Top of Superconductivity Web21

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Feature Articles: Trends in SQUID and Medical Diagnostic Technologies - Advances in Cardiac Examinations Using MRI -

In addition to adult-onset diseases, the increase in aging-related heart disease (or cardiac disease) is an extremely serious issue in the field of medical diagnoses in our graying society. This is because the death rate from cardiac disease, including cardiac angina and myocardial infarction, the two most prevalent types of heart disease, is a high 30 to 40 %. One of the examination techniques being used for such heart diseases is MRI. MRI is an acronym for Magnetic Resonance Imaging.

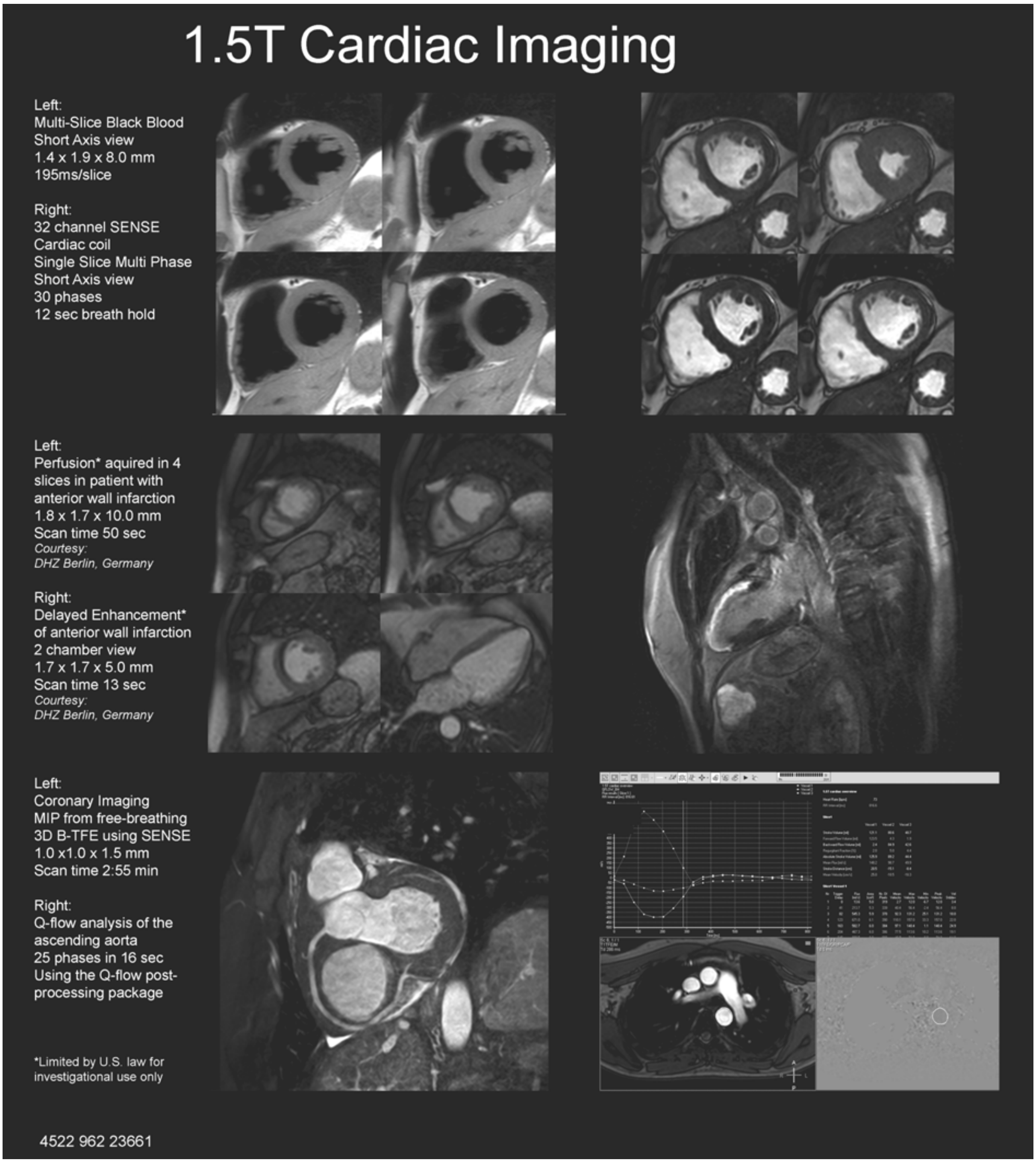
Examination techniques for ischemic heart disease, such as cardiac angina and myocardial infarction, can be broadly classified into invasive exams, such as x-ray computed tomography (CT) and painful cardiac catheterization, and noninvasive techniques including electrocardiography, magnetocardiography; echocardiography, and MRI, which place only a minimal burden on the body. Each technique is good for different types of exams, and in clinical practices, multiple techniques are used together, depending on the type of disease and the patient' status, to get the most accurate diagnosis possible. As a noninvasive technique that can examine myocardial infarction and reduced blood flow in coronary arteries, MRI is receiving special attention because it is a candidate for replacing the currently popular CT and cardiac catheterization techniques.

MRI control technology and clinical databases for the diagnosis of heart disease have already been established for 1.5 T MRI. And recently, control technology has been established for high-magnetic field 3 T MRI, further stimulating the accumulation of clinical information. In this field, Philips Electronics Japan , Ltd. has taken the lead, and clear images like the one shown in the photo are being obtained. The company also jointly developed a 32-channel RF coil for exams by MRI signals with Mie University, and this enabled image capture time to be reduced to a mere 3 to 4 minutes, about one-third the previous time. This means patients suffer shorter amounts of time confined in an immobile state while undergoing an exam. Furthermore, it obtains clear vascular images at one-tenth (about 10 ml) of CT by perfecting contrast medium technology.

According to Satoshi Yoshise, Director, Strategic Reference Site Dept., Marketing Division, Philips Electronics Japan Ltd., such superb technology has its foundations in the cardiovascular technology at which his company already excelled. Compared to other organs, it is more difficult to obtain clear images of the heart, but the technology has been established for matching the timing of specimen motion, including the beating heart and respiratory oscillation. In general, basic imaging is aimed at the time period wherein breathing is calm and ventricular/atrial excitation is low on electrocardiograms (in other words the R-R time period, normally about once per second, wherein there is almost no heart movement except for the R-wave peak time period). Furthermore, to identify disease sites, it is necessary coordinate this with an electrocardiograph exam and also use images captured at an even shorter specific time period (for example, about 0.1 seconds between S and T-waves) between P, Q, R, S, T, and U waves. There are also cases in which it is combined with echocardiography, depending on the diagnostic target.

As you can see, the hardware is in place for examining heat disease using MRI, but that is not enough for making any sort of diagnoses. In sort, without a team that includes an MRI technician, a nurse to administer the contrast medium, and a physician who can make a diagnosis, examinations for heart disease are not possible. To perform efficient and highly reliable diagnoses, Phillips Electronic Japan opened the Heart MR Educational Center at Mie University Hospital, a first in Japan, and the center has already trained 50 MRI technicians. The center is also making efforts to train MRI physicians, and it also has a training system in which a single physician studies 150 medical cases in three days.

The popularization of advanced superconducting equipment, such as that represented by MRI and highly reliable diagnoses, require not only advanced equipment that is technologically complete or nearly so, but also a team system comprised of well-trained technicians, nurses, and physicians.



Images provided by Philips Electronics Japan , Ltd.

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Top of Superconductivity Web21

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Feature Articles: Trends in SQUID and Medical Diagnostic Technologies - Current State and Outlook for Breast Cancer Diagnoses by MRI -

Mitsuhiro Tozaki, Director
Breast Center, Kameda Medical Center

MRI, the Most Reliable Diagnostic Technique for Breast Cancer

Breast cancer is increasing each year in Japan, and it is the number one form of cancer suffered by female patients. In the U.S., it is estimated that one in eight woman will get breast cancer, but its prevalence is rapidly rising in Japan due to changing lifestyles. In the future, it is estimated that one in 20 woman will suffer from the disease. That is why an emphasis is being placed on breast cancer screening, and x-ray exams (mammography) and ultrasound exams are is use.

On the other hand, the breast cancer detection rate by MRI far exceeds mammography and ultrasound exams. MRI for diagnosing breast cancer (breast MRI) requires the use of a contrast medium and cannot be used in routine medical exams, but it is the most reliable method for diagnosing breast cancer. This is well known in Europe and the U.S., but in Japan, the general public is, of course, not familiar with breast MRI, and even some physicians specializing in breasts do not know of it. Results of a nationwide survey of hospitals specializing in cancer (cancer diagnostic centers) showed that the rate of breast MRI out of all types of MRI exams did not exceed an average of 2.2 %.[1)]

Japan Trails the Rest of the Developed World in Breast MRI

Japan has the most MRI systems out of all the developed nations, but in terms of breast MRI, it is more like a developing nation. One reason is an almost total lack of radiologists well versed in breast MRI. As a result, CT, mammography, and ultrasound exams are used in place of breast MRI. At our hospital, we conduct the most breast MRI exams of any hospital in the world (200 to 250 per month), and we have a breast radiologist specializing in breast MRI who can interpret MRI images. For that reason, we have a wealth of experience in the early detection of breast cancer that would not be possible without MRI. The benefits of MRI can only be understood by actually using it. We would like to spread the methods for properly using MRI and accurately interpreting MRI images nationwide so that we can join the other advance nations in the use of breast MRI as soon as possible.

Furthermore, a guideline relating to breast MRI was reported in Europe this year. Since there are breast cancers that can only be found by breast MRI, the guideline stipulated that a method for collecting a tissue sample while conducting breast MRI (MRI-guided biopsy) was essential.[2)] We are the only hospital in Japan that performs MRI-guided biopsies.[3)]Similar to results overseas, at our hospital, breast cancer is detected in about 30 % of our patients. We believe that we must safely and quickly spread this technique, which is already considered essential in Europe and the U.S.

Reference :

1) Mitsuhiro Tozaki, Seigo Nakamura, Hiroko Tsunoda, et al., "Report on the State of MR Mammography," JCR News, 164, 21-23, 2008.
2) RM . Mann, CK. Kuhl, K. Kinkel, *et al*. Breast MRI: guidelines from the European Society of Breast Imaging. Eur Radiol. 2008; 18(7):1307-1318.
3) M, Tozaki, N, Yamashiro, E. Fukuma, MR-guided vacuum-assisted breast biopsy using a non-titanium needle. Magn Reson Med Sci,6,259-264, 2007.

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Top of Superconductivity Web21

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Patent information

Published Unexamined Patents in the 1st Quarter of Fiscal 2008.

The following are ISTEC's patents published from April through June 2008. For more information, access the homepage of the Patent Office of Japan and visit the Industrial Property Digital Library (IPDL).

1) Publication No. 2008-78639 "A Josephson Junction Device, Its Formation Method, and a Superconducting Junction Circuit"

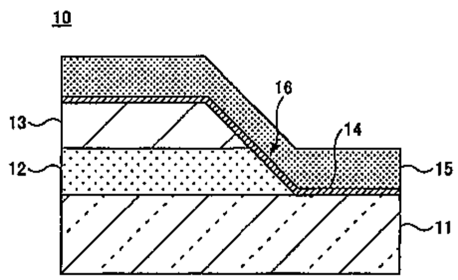
This invention relates to a Josephson junction device, its formation method, and a superconducting junction circuit and is intended to improve the *IcR*n product (product of critical current and resistance at room temperature).

When applying a Josephson junction to a device, it must offer high-speed operation at high temperatures to cut system costs and be highly sensitive. For that reason, Josephson junction device with even higher *IcR*n products are desired, but there is no reference material to show that an adequate *IcR*n is being obtained.

The Josephson junction device in this invention is comprised of lower electrode layer 12 that was formed on substrate 11, insulating film 13, barrier layer 14 that covers the slope that was formed on one end of lower electrode layer 12, upper electrode layer 15 that covers barrier layer 14, and superconducting junction 16. The upper and lower electrode layers (15 and 12) consist of oxide superconducting material that is mainly made of $(RE)_1(AE)_2Cu_3O_y$. Barrier layer 14 consists of material that includes the elements RE, AE, Cu, and O, and out of the cations within this material, the Cu content is set from 35 to 55 atom % and the RE content from 12 to 30 atom %. In addition, the upper and lower electrode layers have different composition.

Note: RE contains at least one out of Y, La, Pr, Nd, Sm, Gd, Dy, Ho, Er, Tm, Yb, and Lu.
AE contains at least one out of Ba, Sr, and Ca.

Cross-section diagram of the Josephson junction element
related to the form of the first implementation of this invention



(Ichiro Nagano, Associate Director, Research and Development Promotion Division, SRL/ISTEC)

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Top of Superconductivity Web21