Spring, 2005 Date of Issue: April 15, 2005

Superconductivity Web21

Published by International Superconductivity Technology Center
5-34-3, Shimbashi, Minato-ku, Tokyo 105-0004, Japan Tel: 03-3431-4002, Fax: 03-3431-4044

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Published by International Superconductivity Technology Center
5-34-3, Shimbashi, Minato-ku, Tokyo 105-0004, Japan
Tel: +81-3-3431-4002 Fax: +81-3-3431-4044
Top of Superconductivity Web21: http://www.istec.or.jp/Web21/index-E.html

This work was subsidized by the Japan Keirin Association using promotion funds from the KEIRIN RACE

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

Power

American Superconductor Corporation (February 3, 2005)

American Superconductor Corporation (AMSC) has reported its financial results for its third fiscal quarter, ending December 31, 2004. Revenues increased by 89%, compared with the same quarter in the previous fiscal year, to a record US $23.2 million. The net loss decreased to $2.5 million, compared with a net loss of $6.5 million for the same quarter in the previous fiscal year. AMSC received $3.7 million in new orders and contracts during the quarter, bringing their total backlog of orders and contracts to $36.9 million, of which $13 to $15 million is expected to be recognized as revenue in the fourth fiscal quarter. The company ended the third quarter of fiscal 2005 with cash, cash equivalents and short and long-term investments equivalent to $45.5 million and no long-term debt. AMSC currently expects revenues in the range of $58 to $61 million and a net loss in the range of $16 to $18 million for the present fiscal year.

AMSC shipped a record 163,000 meters of first-generation HTS wire in the third quarter, which is nearly as much as the total for the prior two quarters combined and more than the total shipment for the previous fiscal year. Greg Yurek, chief executive officer of AMSC, commented, "With the successes we have achieved in seeding the market with first-generation HTS wire and the excellent progress we have made in developing our second-generation HTS wire this fiscal year, we have made the decision to accelerate our migration to second-generation HTS wire. We expect both current and future customers to rapidly adopt products based on our second-generation HTS wire when it is made available in commercial quantities."

Source:
"American Superconductor Reports Fiscal 2005 Third Quarter and Nine-Month Results"
American Superconductor Corporation press release (February 3, 2005)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=670058&highlight

American Superconductor Corporation and Siemens AG (February 8, 2005)

American Superconductor Corporation (AMSC) and Siemens AG have announced the formation of a strategic alliance to develop and explore the commercialization of HTS fault current limiters (FCLs) based on AMSC's second-generation HTS wire and Siemens' fault current limiter design. Prior to establishing this alliance, the two companies obtained input from electric utilities across Europe, Canada, and the U.S. and used this information to define specific customer needs and create a roadmap for FCL demonstrations. The alliance will enable both companies to capitalize on earlier work and proprietary technologies. Under the terms of the agreement, Siemens will develop the performance requirements for its FCL design and AMSC will tailor its standard second-generation HTS wire to meet those specifications. The first deliveries of second-generation HTS wire to Siemens should be made in 2005.

Source:
"American Superconductor and Siemens Form Strategic Alliance to Develop and Commercialize Advanced Grid Reliability Technology"
American Superconductor Corporation press release (February 8, 2005)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=671609&highlight

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SuperPower, Inc. (February 8, 2005)

Two researchers from SuperPower, Inc., a subsidiary of Intermagnetics General Corporation, have received the Eastern New York Intellectual Property Law Association (ENYIPLA) Inventor of the Year Award for 2005. Dr. Xing Yuan, senior applications scientist, and Drew W. Hazelton, principal engineer, received the award for their work on SuperPower's matrix fault current limiter (MFCL). Dr. Yuan joined Intermagnetics in 1996 and is presently leading the technical design team for the MFCL. Mr. Hazelton joined Intermagnetics in 1980 and has managed a variety of programs involving superconducting components technologies. The criteria for ENYIPLA's Inventor of the Year award are creativity, economic value, the difficulty of the problem, the contribution to the well being of society as a whole, and the status of the invention and the inventor in his/her field.

Source:
"SUPERPOWER INVENTORS RECEIVE 2005 'INVENTOR OF THE YEAR' AWARD"
SuperPower, Inc. press release (February 8, 2005)
http://www.igc.com/news_events/news_story.asp?id=152

Trithor (February 10, 2005)

Twenty exhibitors from Germany, Japan, New Zealand, and the USA will display superconductivity products and innovative services in the fields of energy technology, power transmission, transport engineering, sensor technology and electronics at the Hannover Fair (April 11 – 15, 2005), the world's leading showcase for industrial technology. The "SuperConductingCity" will be one of three central themes in the Research and Technology pavilion and will highlight the numerous practical applications of superconductivity. Exhibits will include a working model of a Maglev train and the world's largest HTS current limiter. Trithor plans to present a broad portfolio of superconducting components, including superconducting wire, HTS motor coils, and a cable section.

Source:
"Superconductivity in the Spotlight of Hannover FairHall 2—International Group Pavilion to Demonstrate Applications"
Trithor press release (February 10, 2005)
http://www.trithor.de/pdf/2005-02TrithorHannovermesse_ENG.pdf

Intermagnetics General Corporation (February 15, 2005)

Intermagnetics General Corporation (IMGC) has completed the previously announced sale of its Polycold Systems subsidiary to Helix Technology Corporation for US $49.2 million cash, plus the assumption of certain post-closing tax obligations. The sale was projected to result in a pre-tax gain of about $40 million. The sale of Polycold Systems was part of IMGC's planned divestment of certain businesses in order to focus financial and management resources on the medical devices market. Glenn H. Epstein, chairman and chief executive officer of IMGC, commented, "The proceeds from this sale will enable us to substantially pay down long-term debt related to last year's acquisitions of Invivo and MRI Devices, which significantly strengthened our position in the medical devices marketplace."

Source:
"Intermagnetics Completes Sale of Polycold Subsidiary"
Intermagnetics General Corporation press release (February 15, 2005)
http://phx.corporate-ir.net/phoenix.zhtml?c=88261&p=irol-newsArticle&ID=675336&highlight

American Superconductor Corporation (February 23, 2005)

American Superconductor Corporation (AMSC) has announced a new order for a D-VAR voltage

regulation system to be installed at the Kettles Hill wind farm in Alberta, Canada. The order marks the eighth wind farm customer to select AMSC's D-VAR solution. When completed in the spring of 2006, the facility will include 35 Vestas wind turbines and will be capable of generating up to 63 MW of zero-emission energy. AMSC's D-VAR system will dynamically regulate the voltage for the entire wind farm at the point of its connection to the Alberta transmission grid, maintaining a steady voltage despite fluctuations in wind speed. In total, the eight wind farms incorporating AMSC's advanced D-VAR voltage control technologies are capable of producing 610 MW of energy, enough to meet the energy needs of 300,000 homes.
Source:
"American Superconductor Receives New D-VAR(R) Order for Connection of Canadian Wind Farm with Electric Transmission Grid"
American Superconductor Corporation press release (February 23, 2005)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=677853&highlight

American Superconductor Corporation (February 24, 2005)

American Superconductor Corporation (AMSC) has made a public offering of 4,000,000 shares of common stock at a price of $10.50 per share. The offering closed on March 1, 2005. The proceeds from the offering were expected to amount to approximately US $39.6 million. AMSC plans to use the proceeds for working capital and for general corporate purposes, including the scale-up of second-generation HTS wire manufacturing.
Source:
"American Superconductor Announces Pricing of Public Offering of $42,000,000 of Common Stock"
American Superconductor Corporation press release (February 24, 2005)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=678486&highlight

Electronics

HYPRES, Inc. (February 7, 2005)

HYPRES, Inc. has received two contracts valued at more than US $2.2 million from the US Department of Defense to develop new, digital RF linearization technology for the military's future wireless communications systems. Under these contracts (a Navy Phase II SBIR contract and an Army Phase II SBIR contract), HYPRES will use its superconductor microelectronics (SME) technology to develop and produce the wireless industry's first RF digital linearization circuits for wideband applications. RF linearization is expected to greatly improve high power amplifier efficiency, improving range and link closure with reduced power in multi-channel and wideband signal transmissions. The two contracts are related to the previously announced Missile Defense Agency RF linearization STTR project, which has been undertaken by HYPRES and the University of Rochester (NY).
Source:
"Recent DoD Contract Wins Pave Way For HYPRES To Develop New RF Linearization Technology For All JTRS Frequencies"
HYPRES, Inc. press release (February 7, 2005)
http://www.hypres.com/pages/new/bnew_files/RFLinearization.pdf

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Communication

ISCO International, Inc. and Superconductor Technologies Inc. (February 4 and 7, 2005)

The Appellate Court has ruled on the appeals issued by both ISCO International Inc. and Superconductor Technologies Inc. (STI) concerning the 2003 jury trial and subsequent Trial Court decision in the '215' patent litigation case that ISCO International brought against STI. The Appellate Court reaffirmed the jury verdict that ISCO's US patent for a "Cryoelectronically Cooled Receiver Front End for Mobile Communications System" was invalid and unenforceable. The Appellate Court further agreed with the Trial Court in denying STI's claims of unfair competition. As a result of this decision, neither party owes the other.
Source:
"ISCO INTERNATIONAL ANNOUNCES COURT RULINGS IN PATENT LITIGATION APPEAL PROCESS"
I SCO International Inc. press release (February 4, 2005)
http://www.iscointl.com/
"Superconductor Technologies Inc. Receives Affirmative Ruling on '215 Patent Infringement Lawsuit"
Superconductor Technologies Inc. press release (February 7, 2005)
http://phx.corporate-ir.net/staging/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=670879&highlight

ISCO International, Inc. (February 10, 2005)

ISCO International, Inc. and its lenders have agreed to extend a credit line that was previously due on April 1, 2005. The extended credit line will now be due on April 1, 2006. John Thode, the new President and Chief Executive Officer of ISCO, commented, "I'm pleased that we were successful in negotiating this extension with our lenders. I believe it reflects well on some of the significant strides that ISCO has made and the potential of this company going forward."
Source:
"ISCO INTERNATIONAL REPORTS ELECTION OF JOHN THODE TO BOARD OF DIRECTORS AND CREDIT LINE EXTENSION"
ISCO International, Inc. press release (February 10, 2005)
http://www.iscointl.com/

ISCO International, Inc. (February 17, 2005)

ISCO International, Inc. has reported its financial results for the fourth quarter and full year. The company recorded net revenues of US $650,000 and $2.6 million for the three-month and twelve-month periods ending December 31, 2004, respectively, compared with $1.3 million and $3.2 million for the same periods in the previous fiscal year. The Company's reported net losses were $2 million and $7 million for the three-month and twelve-month periods ending December 31, 2004, respectively, versus net losses of $319,000 and $7.2 million for the same periods in the previous fiscal year. ISCO also reported a record backlog in orders for 2005, with first-quarter deliveries expected to be in excess of $2.5 million. Most of these orders are related to the deployment of 3G data services within wireless telecommunications networks.
Source:
"ISCO INTERNATIONAL REPORTS FOURTH QUARTER AND FULL YEAR 2004 RESULTS; RECORD BACKLOG ENTERING 2005; AND INVESTOR CONFERENCE CALL ON FEBRUARY 25TH AT 4PM EASTERN"
ISCO International, Inc. press release (February 17, 2005)
http://www.iscointl.com/

ISCO International, Inc. (February 25, 2005)

ISCO International, Inc. has forecasted its first quarter revenue for 2005 to be approximately $3 million. John Thode, President and CEO of ISCO, announced, "By next week, deliveries for the First Quarter 2005 should match all of 2004, and we expect that number to grow as we finish the quarter. As expected, we are already seeing continued customer order activity for Second Quarter 2005 delivery, in conjunction with customer project plans."

Source:
"ISCO INTERNATIONAL REPORTS $3 MILLION FIRST QUARTER 2005 REVENUE FORECAST; BACKLOG FOR SECOND QUARTER BUILDING"
ISCO International, Inc. press release (February 25, 2005)
http://www.iscointl.com/

Quantum Computer

National Institute of Standards and Technology (February 24, 2005)

A research team at the National Institute of Standards and Technology (NIST) and the University of California, Santa Barbara (UCSB) has described the characteristics of two superconducting devices made from Josephson junctions that were coaxed into a special, interdependent state in which the wave patterns produced by the devices mimic the natural oscillations between quantum states in atoms. The experiments are an important step toward the possible use of "artificial atoms" made with superconducting materials for data storage and processing in future ultra-powerful quantum computers. Until now, superconducting qubits (the quantum counterparts of the 1s and 0s used in today's computers) have been measured one at a time to avoid unwanted effects on neighboring qubits. The NIST experiments demonstrated that the quantum properties of two interconnected artificial atoms could be measured virtually simultaneously. Thus, the properties of artificial atoms could be coordinated in a manner consistent with the quantum phenomenon known as "entanglement", allowing the construction of logic gates in a quantum computer. While research using real atoms as qubits has advanced more rapidly, superconducting circuits offer the advantage of being easily manufactured, easily connected to each other, easily connected to existing integrated circuit technology, and mass producible using semiconductor fabrication techniques. Ray Simmonds, a physicist at NIST, commented, "Whether or not quantum computing becomes practical, this work is producing new ways to design, control and measure the quantum world of electrical systems. We have already detected previously unknown, individual nanoscale quantum systems that have never before been directly observed, a discovery that may lead to unanticipated advances in nanotechnology." The research was reported in the February 25 issue of *Science*.

Source:
"NIST-UCSB Scientists Entice Superconducting Devices To Act Like Pairs of Atoms"
National Institute of Standards and Technology press release (February 24, 2005)
http://www.nist.gov/public_affairs/releases/qubits.htm

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

(Published in a Japanese version in the April 2005 issue of *Superconductivity Web 21*)

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Feature Articles : ISS2004 Topics

- The 17th International Symposium on Superconductivity (ISS 2004) -

The International Superconductivity Technology Center (ISTEC) held the 17th International Symposium on Superconductivity(ISS2004) at the Niigata Convention Center (Toki Messe) for three days from November 23 (Tuesday) through 25 (Thursday), 2004. ISS is held each year and this year was the 17th anniversary. The purpose of ISS is to promote the development and commercialization of superconductive technology, promote the use of the technology among the general public, and also familiarize them with it. These goals are accomplished through domestic and overseas research into superconductivity, the presentation of results obtained from technological development, and international exchange. A total of 613 participants from 24 countries, including 115 overseas participants, attended this symposium, representing an increased number of overseas participants. There were also a total of 498 presentations and sessions, made up of 144 oral sessions and 354 poster sessions, including 73 invited speakers; an increase of 54 over the previous year's figure. Papers from the symposium will be collated and published as a special volume of Physica C (Elsevier B.V.), an academic journal. At the same time, 9 companies exhibited superconducting materials, products, and technology.

On the first day, an opening address was delivered by Prof. Tanaka, Vice president of ISTEC, and a congratulatory address from Minister Nakagawa of the Ministry of Economy, Trade and Industry was delivered on his behalf, (read by Mr. Shoji Kusuda, Director-General for Economic Policy Department, Ministry of Economy, Trade and Industry, Kanto Bureau). Subsequently, 2 special plenary and 6 plenary lectures respectively were delivered, with the program chaired by Prof. Koji Kishio (the University of Tokyo) and Dr. X. Obradors (Institute de Ciencia de Materials de Barcelona). The special plenary lectures concerned the "New Era for the Applications of Superconductivity" presented by Prof. Shoji Tanaka (ISTEC-SRL), and the "Development of High Temperature Superconducting Wires in the U.S." presented by Dr. D.E.Peterson (Los Alamos National Laboratory). The plenary lectures meanwhile focused on the "Highlights of Coated Conductors R&D in Europe" presented by Prof. H.C.Freyhardt (University of Goettingen), the "Activity of R&D for Coated Conductors in Japan" presented by Dr. Yuh Shiohara (ISTEC-SRL), the "Emission of Continuous Terahertz Waves by High Tc Superconductors" presented by Dr. Masashi Tachiki (National Institute for Materials Science (NIMS)), the "Recent Developments of Bulk RE-Ba-Cu-O Superconductors" presented by Prof. Masato Murakami (Shibaura Institute of Technology), the "SQUIDs: Novel Applications" presented by Prof. J.Clarke (the University of California, Berkeley), and the "Development of SFQ Microprocessors" presented by Prof. Akira Fujimaki (Nagoya University). A banquet was also held in the evening to encourage active exchange among the participants.

Opening ceremony

Prof. Shoji Tanaka, vice-president of ISTEC delivering an opening address

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On the second and third days, oral presentations were given and two poster sessions were held under 4 categories of physics & chemistry and vortex physics respectively, including bulks/system applications; wires & tapes/system applications; and films & junctions/electronic devices. The participants engaged in earnest discussions during these presentations and sessions.

In the physics and chemistry session, two mini-symposiums, entitled "Vortex Physics: from Simple Metals to High-Tc Oxides", and "Superconductivity in nano-scale" were held, and represented opportunities for dialogue on the latest topics, such as new superconducting materials and elucidation of the superconducting mechanism of a high-Tc copper oxide. In the bulk/system applications session, the latest topics, including magnetic levitation at liquid oxygen temperature and manufacturing of large bulk in microgravity space as well as recent findings concerning the application of superconducting bearings, a superconducting electric generator, and a movable magnetic separator to a flywheel were reported and discussed. As for the wires & tapes/system applications session, the latest development results concerning the use of wire and tapes in Japan, the U.S.A., and Europe, and the applicability of superconductivity to power equipment were reported and lively discussions held. In the films & junctions/electronic devices session, the development of microprocessors through the use of SFQ devices, the applicability of superconducting devices to microwave equipment, the extensive applications of SQUID, and many others were reported.

In the afternoon of the third day, upon closing ISS2004, Dr. Kazuto Hirata (NIMS) summarized the presentations from the physics & chemistry and vortex physics session, Prof. D.A.Cardwell (IRC in Superconductivity) in the bulks/system applications session, Dr. D.E.Peterson (Los Alamos National Laboratory) in the wires & tapes/system applications session, and Dr. Keiichi Tanabe (ISTEC-SRL) in the films & junctions/electronic devices session respectively. Finally, Prof. Shoji Tanaka (ISTEC-SRL), who was chairperson of the organizing committee of ISS2004, delivered the closing address, stating his eagerness to meeting again at ISS2005, which is scheduled to be held in Tsukuba City for three days from October 24 through 26, 2005. The curtain then fell on a successful ISS2004.

Oral session

Poster session and exhibition

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

(Published in a Japanese version in the December 2004 issue of *Superconductivity Web 21*)

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Feature Articles : ISS2004 Topics

- Physics and Chemistry -

Kazuto Hirata
Superconducting Material Center
National Institute for Materials Science (NIMS)

The physics and chemistry session was divided into the categories of Physics and Chemistry (PC) and Vortex Physics (VP). The session also included two mini-symposiums: "Vortex Physics: from Simple Metals to High-Tc Oxides", and "Superconductivity in nano-scale".

The "Superconductivity in nano-scale" focused on the structures observed in high temperature superconductors at nanoscale, the checker boards (STM), the dynamic and static stripe structures (neutron scattering) related to superconductivity, and the nanoscale fine-structures for vortex-pinning and the pinning effect. A report given during the mini-symposium of PC presented the STM observation of checker board in what is called the pseudo-gap state at the higher temperature side from the superconducting phase of about 100K. It was also suggested the presence of a striped structure based on neutron scattering and the temperature-dependency of resistance in the magnetic field. Although the phenomenon might be suggested from the inhomogeneity of the composition dependent on the carrier concentrations, the possibility of inhomogeneity was ruled out from the resistance and specific heat measurements. For the generation of a superconducting phase in the normal state of La-system, the scanning SQUID measurement denied the generation. For the hidden order in the phase of superconducting and normal state, it may take time to making the order in the electron state clear. The search for new superconducting materials was performed with considerable effort, and there were presented concerning a Li-Pd(Pt)-B material with 7.8K of superconducting transition temperature, a boron-doped diamond thin film with a maximum superconducting transition temperature of around 10K, and a pyrochlore oxide with a maximum superconducting transition temperature of 9.6K.

In the VP session, a mini-symposium was planned as a commemorative meeting for Dr. Abrikosov to celebrate his Nobel Prize award last year. Unfortunately, however, he was unable to attend the symposium. Summarizing a contemporary theoretical vortex physics, there was a presentation involving a comprehensive description on the magnetic phase diagram of the Josephson vortex system relating to thermal fluctuations and anisotropy in superconductivity. For the vortex cores, the electronic core state was calculated to take into account the spin and charge density wave. For the metal-based materials, a numerical calculation of the upper critical magnetic field, taking the Fermi surface shape into consideration, represented an effective explanation of the experimental results, rendering the calculation a useful future tool for the experimental researchers. In the experiments of VP, a lecture was delivered concerning the point, line, and plane pinning centers (columnar defect resulting from heavy ion irradiation, twin, impurities) of the vortex in high temperature superconductors, and their magnetic phase diagram, during which time the magnetic phase diagram of the pinned vortex was discussed. The pinning centers are important when considering practical applications, and the kinds of magnetic phase formed thermodynamically remain open for further detailed discussion. Lectures included the dynamic friction state in vortex dynamics, the liquid state of the quantum vortex, and experimental verification of the FFLO phase on a $CeCoIn_5$ superconductor magnetic phase diagram. Steady development was acknowledged, not only in the vortex physics of high

temperature superconductors but also in metal-based materials. Linking with the development of measurement technology and of fabrication technology of fine structure, and joining the *d*-dot vortex physics, vortex physics can be said to be entering a new era.

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Feature Articles : ISS2004 Topics

- Bulks and System Applications -

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

The session of bulk superconductors and system applications showed a totally steady development in each of the processes of evaluation, performance improvement, and application fields.

Regarding the processing, Fujikura et al. of Shibaura Institute of Technology reported that a complex-shaped product can be fabricated through a relatively simple procedure in that the addition of a small amount of organic binder to a precursor is performed prior to mechanical machining. Sakai et al. of ISTEC reported that they observed Gd_2BaO_4 acicular crystals in one of the samples produced in a space experiment. Based on this they developed a novel process to impregnate Ba-Cu-O into the precursor composed of Gd_2BaO_4, and succeeded in the production of a large single grain Ga-Ba-Cu-O bulk superconductor 140 mm in diameter.

Cardwell et al. of Cambridge University reported that nano-order sized $YBa_2(Cu_x,M_{1-x})O_6$ particles can be uniformly distributed in a matrix, which dramatically increased the critical current density of YBCO. Xu et al. meanwhile, of the Tokyo University of Marine Science and Technology, reported a similar trial to that of Cardwell et al. using $GdBa_2(Cu_x,M_{1-x})O_6$, but the size was not comparable to that of Y-based materials. Nariki et al. of ISTEC reported that $BaCeO_3$ acted as an effective pinning center and that the substitution of Zr for Ce site led to the refinement of the particle. Miryala et al. of ISTEC reported that fine dispersion of Zr-containing Gd-Ba-Cu-O particles in (Nd, Eu, Gd)-Ba-Cu-O led to superior critical current characteristics, even at 90K. Cardwell suggested that the fine particles may have a chemical formula of $REBa_2(Cu_x,M_{1-x})O_6$ which was reported as a very effective pinning center by his group in this session.

For the characterization of bulk superconductors, Weber et al. of Atomic Institute for Austrian Universities reported a novel method to characterize large bulk superconductors with a low electromagnetic force in a non-destructive mode. The method is that one scans a permanent magnet and a Hall probe sensor simultaneously on the sample surface and measures the field distribution, which has advantages compared with the trapped magnetic field measurement, in terms of the minimal bulk damage and the ability to attain microscopic information which cannot otherwise be acquired from the measurements of trapped magnetic field distribution. A similar method was reported by Kono et al. of ISTEC. Fujishiro et al. of Iwate University reported that they had filed a database for mechanical and thermal properties of bulk superconductors, which is open to public.

In the session of applications, Gawalek et al. of IPHT reviewed the development of a hysteresis motor in Europe and a magnetically levitated train using bulk superconductors in Russia. Kummeth et al. of Siemens reported a project for the construction of a 400 kW superconducting motor, for which high performance bearings using bulk superconductors will be installed. Ichihara et al. of ISTEC reported the structure of superconductive magnetic bearings for a 10 kWh flywheel, the construction of which has been performed as Japanese national project, and they reported that the bearings performance achieved the

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target level. Yanagi et al. of the IMRA Material R&D Co., Ltd. reported on the excitation method for a Sm-based bulk superconductor 60 mm in diameter to stably trap 8T magnetic field, which was successfully used as a magnetic field source for a high performance magneto-sputtering device.

Matsumura et al. of Minnesota University characterized a high temperature superconductive bearing for use in a cosmic microwave background polarimeter, and concluded that the bearing is suitable for this purpose. Finally, Maehata et al. of Kyushu University reported on the development of YBCO-based current that has a capacity of 20,000 A to flow at 1.8K.

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Feature Articles : ISS2004 Topics

- Wires, Tapes and System Applications -

The Wires, Tapes and System Applications session encompassed more than 150 presentations, including 38 delivered orally, an upward trend based on the previous year's figures. This trend suggests that the sector in question is one with strong expectations concerning future applications. Specifically, more than half of the presentations were occupied by Y-based wires. The following represents the major contents of the session with a focus on Y-based wires.

The development of Y-based wires has led to a competing trio involving three major countries, namely: Japan, the U.S., and Europe, with Korea and China following in their footsteps. In particular, Japan and the U.S. are way ahead of the field in the domain of long-length wire development. The latest state of development in Japan, the U.S., and Europe was introduced in the Plenary Lectures, by Drs. Shiohara (SRL-STEC), Peterson (LANL), and Freyhardt (University Goettingen), respectively. Regarding the overview of the Ic-L product development, which recently also became an index to development, the IBAD-PLD wire of Fujikura Ltd. had achieved a maximum 3800 Am (100 m x 38 A) last year, followed by 2250 Am (10 m x 225 A) of the University Goettingen, while this summer an IBAD-PLD wire of IGC Super Power Inc. of the U.S. achieved 7000 Am (100 m x 70 A), and an oriented metallic substrate incorporating a laid superconductive layer (using the TFA-MOD method) of AMSC Inc. attained 5100 Am (46 m x 182 A/cmw), thus breaking the record. Based on these facts, rollback of Japan in the ISS was expected. Consequently, Fujikura Ltd. achieved a record of 13230 Am (105 m x 126 A), and SRL-Nagoya succeeded in obtaining 8335 Am (46 m x 182 A), thus once again securing second place.

As for other topics, SRL achieved a high Ic of 413 A with a wire incorporating an IBAD-based buffer layer substrate, with the TFA-MOD method applicable for the superconducting layer forming technology, and the fabrication of a 16 m-long wire. Super Power Inc. fabricated a high characteristics long wire (62 m x 100 A/cmw = 6200 Am) using MOCVD. Wires using an oriented metallic substrate were represented by the above AMSC Inc. result, and as for other methods, the results of that featuring co-vapor deposition of EDISON Inc. of Italy drew attention. This method actualized a CeO_2 monolayer buffer layer structure through co-vapor deposition; utilizing the features of low temperature synthesis and thereby obtaining a wire 2 m in length, providing 120 A/cmw.

A recent trend has seen enhanced research and development of artificial pin control technology targeting improved characteristics within a magnetic field. Such improved characteristics were detected in the generated magnetic field during implementation of the method for dispersing nanoparticles of $(Y,Ho)_2Cu_2O_5$ into MOD film, (AMSC Inc.), that for dispersing BZO and Y211 particles into PLD film, (ORNL, Air Force), and that for introducing defects by dispersing Y_2O_3 into a substrate, (Kyoto University), thereby improving the characteristics of the generated magnetic field. For the improvement of characteristics in RE-based materials other than Y, two Sm-related presentations were given (in Korea and Nagoya University). Both studies saw characteristics successfully improved. Evaluation technology revealed a feature of the aggressive establishment of evaluation technology through the combination of various technologies, known as "Coordinated Characterization" for both Japan and the U.S., (Kyushu University, and ANL).

Spring, 2005 Date of Issue: April 15, 2005
Superconductivity Web21
Published by International Superconductivity Technology Center
5-34-3, Shimbashi, Minato-ku, Tokyo 105-0004, Japan Tel: 03-3431-4002, Fax: 03-3431-4044

From an applicatory perspective, device-fabrication using Bi wire runs ahead of others, giving a strong impression in terms of motors and generators in the U.S. (AMSC Inc.), and Maglev (JR Tokai) and cables (the Furukawa Electric Co., Ltd.) in Japan. As for the investigations using Y-based wires, reports were issued concerning cables in the U.S. (Super Power Inc.) and solenoid coil prototype fabrication in Japan (Fujikura Ltd.)

The overall impression of the Y-based wire development reveals a feeling of actualizing 100 m-long class high characteristic wires during the process research, thanks to severe developmental competition, prompting the development stage to almost enter that of device fabrication. Since there are several types of fabrication process, the survival development race, with a focus on cost and characteristics will be sustained for a certain period of time. On the other hand, the depth of the evaluation technology in supporting the fabrication technology development has been increasing, and the study concerning the application of the evaluation technology has shown smooth progress, leading to positive expectations for future development.

(Teruo Izumi, Division of Superconducting Tapes and Wires, SRL/ISTEC)

(Published in a Japanese version in the December 2004 issue of *Superconductivity Web 21*)

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Spring, 2005 Date of Issue: April 15, 2005
Superconductivity Web21
Published by International Superconductivity Technology Center
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Feature Articles : ISS2004 Topics

- Films, Junctions and Electronic Devices -

The number of presentations in this session was 106, which was almost the same as that in previous years. Among them, a significant increase in papers relating to MgB_2 was apparent. Dr. Moeckly (STI Inc. of the U.S.) reported on the fabrication of MgB_2 thin film (Tc=39.1K) through the vapor deposition method, as delivering the highest quality among all previously reported examples. According to Dr. Moeckly, a B thin film is deposited on a substrate, which is itself placed on a rotary disc under conditions of intense vacuum, whereupon the B is then brought to react with the newly introduced Mg vapor in a "pocket" in order to obtain MgB_2, upon which the steps are repeated. The method resembles that which had been proposed by Kinder et al. (Munich University) using a Y-based oxide thin film, (O_2 instead of Mg). The method specified by Dr. Moeckly allowed the formation of both-surface films on various kinds of substrates to a max. diameter of 4", not only on sapphire but also crystalline alumina and Si-substrate via a buffer layer. Dr. Wang (NICT) and Dr. Ueda et al. (NTT) reported on the fabrication of the SIS tunnel junction using MgB_2 thin film. They used AlN and AlO_x as barriers respectively and observed Josephson current and quasi-particle tunneling characteristics with relatively small leakage. Their observations, however, were limited to what is known as the "small gap", meaning the fabrication of the large gap junction remained a pending issue. Dr. Kurian et al. (NTT) reported on a reproducible thin film fabrication, revealing a high Tc above 94K and minor microwave surface resistance at 77K. Their fabrication methods involved, upon the formation of Nd-123 thin film on MBE, Ag being simultaneously charged onto the substrate, thereby enhancing the atomic diffusion over the substrate surface.

During the device session, Dr. Clarke (UCB) delivered a plenary lecture, and the presentations included showed a steady development in the SQUID application field. Dr. Tsukamoto (Basic Research Laboratory of Hitachi Ltd.) reported on the new process development concerning the 51ch HTS SQUID cardiac magnetic field inspection system. Drs. Hatsukade, Tanaka et al. (Toyohashi University of Technology) reported on the development of a non-destructive inspection system using a small pulse tube cooler, (defect inspection in the thin tube of heat exchanger), and precision control of cooler temperatures through the application of halogen lamplight to optical fibers. During the microwave application session, attention focused on the recent surge in China recording 300 million cell phone users, and the implementation of a full scale base station field test involving receiving units subject to high temperature superconducting filters. During the digital application session, the development of low temperature SFQ circuits was emphasized by what is called the "CONNECT Group" including SRL, Nagoya University, Yokohama National University, and NICT. For example, the use of passive wiring routes such as a micro-strip line for the integrated wiring successfully suppresses the increase in the number of Josephson junctions and the bias current, which would otherwise hinder the scale enlargement of circuits. In addition, a report was issued concerning the functional ability of a microprocessor of the 7200-junction class containing a small scale memory. In addition, in the case of the next generation Nb-based processor, with flat and multilayered structure including 6-9 layers of Nb wiring and a test chip containing one million SQUIDs, this was evaluated as confirmation of a low defect density. Regarding the high temperature SFQ circuits, a report was issued concerning improvements in the reliability of the thin film lamination and junction process, verifying the function of a circuit of capacity up to 100-junction class and also observing a high frequency 50 GHz signal waveform using a sampler circuit with cooler. For the SFQ circuits, the prime issue remains verification of

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performance overriding that of semiconductors, the application of a cooler-mounted system, as well as the low temperature system.

At the beginning of the session, invitational lectures were given concerning the three kinds of junction bit research involving the use of Josephson junctions, and thanks to the organization of NIST, NTT, and NEC, all leaders in this field. The present state is a verification stage involving interaction and intertwining of the two quantum bits, above all to isolate the cause of the reduced coherence holding time and control over interactions than that seen at a practical level of usage. The research of the session has drawn considerable attention, and the future ISS development reports are eagerly awaited.

(Keiichi Tanabe, Director, Division of Electronic Devices, SRL/ISTEC)

(Published in a Japanese version in the December 2004 issue of *Superconductivity Web 21*)

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Superconductivity Web21
Published by International Superconductivity Technology Center
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CCA2004 Topics

The International Workshop on Coated Conductors for Applications (CCA2004) was held as a satellite symposium of ISS2004 at the Oiso Prince Hotel for two days from November 19 through 20, 2004. A tour given on November 18 saw around 50 participants assemble to visit the Super-GM 500 m high temperature superconducting cable testing station.

A total of around 100 participants attended CCA 2004, with 54 oral and 25 poster presentations. Regarding recent developments in coated conductor performance, Fujikura Ltd. achieved a critical current of 126 A with 105 m of length, and SRL achieved a critical current of 182 A with 46 m of length. For the long wires, reports were issued by ISTEC concerning the fabrication of a 220-long IBAD-GZO buffer layer, , and by Chubu Electric Power Co., Inc. on the development of a 200 m MOCVD process (insertion of IBAD substrate into a dummy substrate section 210 m in length, revealing a critical current of Ic=65 A). Sumitomo Electric Industries, Ltd. reported about both side film fabrication (Ic=81A + 98A) and the fabrication of 10 m coated conductor using a fluorine-free MOD, (segment Ic=90-130A). Many reports concerning the fabrication of 1-10 m class coated conductors were issued by European countries and Korea.

During the Artificial Pinning session, various methods intended to improve magnetic field characteristics were presented. For example, the formation of defects in the shape of Y_2O_3 grain formation on the substrate surface as demonstrated by Kyoto University increased J_c within magnetic field (B//C) by about two-fold, while Air Force Research Laboratory managed to increase the same 2- to 3-fold in an 1T magnetic field through the lamination of 211 and 123 phase. ORNL executed the inclusion of BZR, YSZ, or $CaZrO_3$, while improvements were also reported in the case of magnetic field characteristics by Gd-123 using an Re element other than Y (Kyoto University and ISTEC), by Sm-123 (Nagoya University), and by (Nd,Ev,Gd)-123 (IFW). For the magnetic field characteristics, AMSC reported that they assessed the values of 27-65K and 1-3T as the required levels of performance in superconducting motors and generators, although such performance indexes had been established.

The next CCA is scheduled to be held in Santa Fe of the U.S. from October 30, 2005.

(Masaya Konishi, Nagoya Coated Conductor Center, SRL/ISTEC)

(Published in a Japanese version in the December 2004 issue of *Superconductivity Web 21*)

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Superconductivity Web21
Published by International Superconductivity Technology Center
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Feature Articles: Superconducting Magnetic Energy Storage (SMES)

- Toward the Completion of SMES - Objectives of the Project of Superconducting Power Network Control Technology Development -

Shigeo Nagaya
Leader
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Chubu Electric Power Co., Inc.

The Project of Power System Control SMES Development started in the current fiscal year (2004) as a national project of the Agency of Natural Resources and Energy, led by NEDO. The project succeeds the developmental results of the Project of Technical Development Superconducting Magnetic Energy Storage conducted within the period 1999 to 2003, and aims to complete the SMES technology.

Since the superconductivity technology deals with large currents at high efficiency, the utilization in electric power reduces the loss caused by electric resistance, thereby improving efficiency, and enabling miniaturization of equipment and systems. In particular, expectations for such applications to apply to existing power systems such as power generation, transmission, and transformation, and further to electric power storage have arisen.

Other than SMES, superconductivity involving electrical power storage can be done through a flywheel using superconductivity applied to the bearings. Including the secondary batteries, the advantages of SMES are the ability of the storage section to endure repeated operations and the fact that the stored energy is released within seconds. With those advantages in mind, SMES is the most suitable storage system for stabilizing power systems requiring instantaneous large output and repeated operations. Furthermore, SMES is a highly useful technology to act as a flexible link to distributed power sources and natural energy such as wind power and solar rays. Its introduction into such existing systems in expected to increase in future.

The preceding developmental project focused on the system control of power, centering on the superconducting coils which are the core of the SMES system, and providing a cost investigation. However, the cost was rather hidden within the high performance and effects of SMES. Thus the functions and the margins of coil and conductor were optimized to suit the actions and duties of SMES, and accordingly, technology to significantly reduce the cost of the coil as the SMES core was established. Consequently, SMES has become a piece of superconducting power equipment to herald potential commercialization for the first time, not only from a functional perspective but also from one of costs. Based on the successful result, SMES has entered the stage as a compensator for instantaneous voltage drops. This compensator to instantaneous voltage drops refers to a piece of apparatus designed to compensate for any instantaneous voltage drops caused by lightning, etc. Accordingly, the apparatus is requested to release its stored energy within a second, providing an excellent opportunity for SMES to fully meet its potential in this field of usage. Particularly when the compensator is of a scale covering the total plant, the effectiveness of the SMES principle is maximized, where the storing section is the coil, and the quantity of energy required for the actions and duties fulfills the requirement. The reason is that the actual actions and duties for compensation require about one second and also that the system is designed to

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allow significantly compact apparatus, compared with other methods which have storage section functioning over periods of time ranging from minutes to hours.

This project is a follow up to the developmental results of technology designed to reduce the coil cost, and develops major system equipment such as power converters and cryo-coolers, other than the coil itself, to complete the total SMES system. Particularly in the second half period of the project, construction of a pilot plant is scheduled, and the effect will be confirmed in an actual system-linkage test.

The detail of the plan is introduced in the NEDO homepage (http://www.nedo.go.jp/) focusing on the basic project plan. This paper introduces the detailed procedure behind the project and its ultimate objective.

Currently the project has three core development subjects. The first focuses on hardware development, including the technological development of system structuring which conducts the development of four facilities: a low cost and high capacity converter, a high magnetic field oxide-based coil, a highly reliable and super low temperature cryo-cooler, and a current lead with excellent ability to withstand voltage. The second subject focuses on the software development, including the selection of testing sites in preparing for the actual system-linkage test scheduled for the last half period of the project, the study of the testing and evaluation methods, and that of workability, operability and the potential for maintenance, which are required in practical applications. Through such verifications, conducted from hardware and software perspectives, the SMES performance may be determined. The third subject focuses on the study of the effect of SMES introduction. By investigating the market need and the economy of SMES, taking future market performance into account and by adding the cost consideration to the performance derived from the preceding two subjects, SMES is evaluated in terms of cost and effect necessary for the final judgment of the practical introduction, while competitive technologies are also evaluated. The ultimate goal is stated to be the standardization of the system as an optimized form of SEMS for each field of usage, including not only the use of power but also industrial applications.

The introduction of superconducting facilities to the power domain means the requirements of large scale and very high reliability power must be faced, since the merit of superconductivity technology is indeed its efficient use of large capacity power. Regarding SMES, the initial developmental stage dealt with a large capacity for load leveling day and night. Subsequently, the development turned to focus on the application effect of the system control, where the features of SMES were seen to function most strongly. Furthermore, the development emphasized not simply improvement of the facility characteristics through superconductivity but the marginal optimization necessary for duty, thereby structuring a system suitable for the utility and merits of SMES, even under conditions of reduced superconductivity. Through the development and with a strong recognition of commercialization, industrial applicability offering small scale backup reliability compared to the scale for power applications to compensate for instantaneous voltage drops has been actualized. With the actual applications, the issues of SMES have been identified and a project aiming to resolve the issue will represent completion of the SMES.

(Published in a Japanese version in the February 2005 issue of *Superconductivity Web 21*)

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超電導 Web21 Superconductivity
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Feature Articles: Superconducting Magnetic Energy Storage (SMES)

- SMES Field Test at Kameyama Plant, Sharp Corp. -

Koji Shikimachi
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Large scale semiconductor plants which require high quality electric power face the potential danger of serious damage resulting from instantaneous voltage dips. To compensate for the lack of power in the event of such instantaneous voltage dips, a power storage apparatus capable of instantly outputting considerable power is required. With this pointing mind, SMES possesses the optimal characteristics as an example of unit with effective countermeasure capability. Targeting the early actualization of the apparatus, we have developed a SMES system using a metal superconductor to bridge instantaneous voltage dips, with an output of 5 MVA (available energy of 5 MJ), rendering it sufficient to cover the whole plant. The SMES system includes superconducting coils which continually store energy, a protective circuit, a high-speed switch for swift shutdown of the system-side power in the event of any instantaneous voltage dip, and a power converter which converts the energy stored in the coil to A/C and then supplies the power to the load. The SMES system must be capable of high speed switching, and offer a high capacity, and minimal costs incurred. To achieve such aims, the development of a power converter and high speed switch respectively is essential. For the coil cooling process, a refrigerant re-condensation system using a small cryo-cooler was applied, eliminating the need for legally prescribed and assigned personnel and the makeup of the refrigerant, thereby simplifying the maintenance and reducing costs.

Fig.1 5 MVA - 5 MJ SMES system for bridging instantaneous voltage dips

The SMES system was installed at the advanced large liquid crystal plant of Sharp Corp. at Kameyama City, Mie, in July 2003 (Fig. 1), and field testing began in July. During operation, the intervention of the SMES system in performing the bridging action upon the occurrence of instantaneous voltage dips within the actual system was confirmed. Figure 2 shows an example of this action. An instantaneous voltage dip occurred in the system voltage, and the SMES

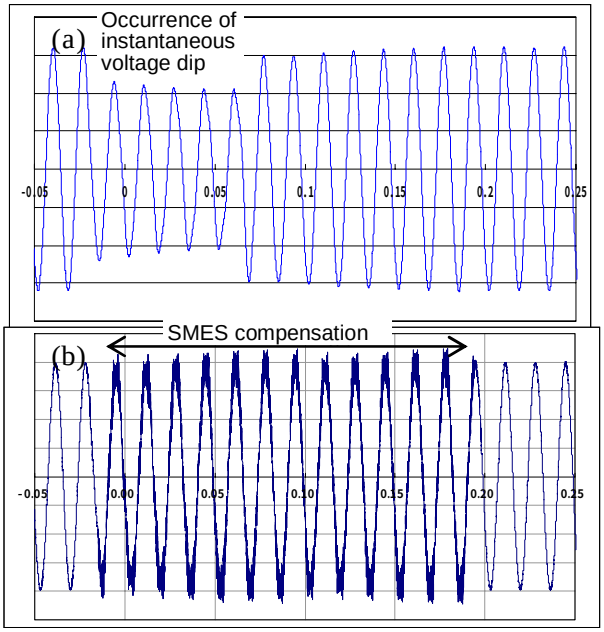

Fig.2 Voltage on (a) system and (b) load upon the occurrence of the instantaneous voltage dip

instantaneously supplied power to the load to maintain the load voltage at a specified level. Since practical applications may be subject to repeated instantaneous voltage dips caused by multiple lightning, the compensatory apparatus countering the instantaneous voltage dips must be capable of implementing sufficient action to tackle such repeated occurrences. The field test also confirmed the performance following repeated actions and operation. The test system underwent successive instantaneous voltage dips due to successive faults caused by lightnings, and the compensation functioned perfectly by sustaining bridging action during the period. The repeated instantaneous voltage dips occurred three times at one minute intervals, and the SMES system repeated the implementation of bridging action to counter this three times without any problem by repeating the charge and discharge cycles.

Through the test operation, the technological proficiency of the specification requested to provide effective compensation to counter instantaneous voltage dips was proven in the case of the SMES system.

(Published in a Japanese version in the February 2005 issue of *Superconductivity Web 21*)

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Published by International Superconductivity Technology Center
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Feature Articles: Superconducting Magnetic Energy Storage (SMES)

- Development of Conduction-Cooled LTS Pulse Coil for UPS-SMES as a Protection from Instantaneous Voltage Drops at National Institute for Fusion Science (NIFS)-

Toshiyuki Mito, Division Director / Professor
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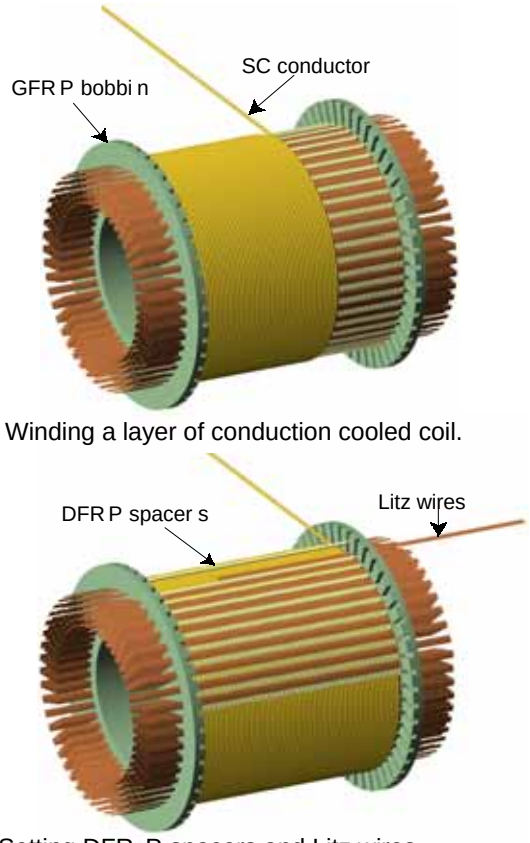
National Institute for Fusion Science (NIFS)
National Institutes of Natural Sciences

With the cooperation of Technova Inc., and Kagoshima and Kyushu Universities, National Institute for Fusion Science has conducted R&D (into) for SMES providing instantaneous voltage drops compenstation, 1 MW with 1 sec, as part of the NEDO Basic Technology Research Promotion Project. As a key component in the SMES compensatory technology used in the event of instantaneous voltage drops, the development of a low temperature conduction-cooled superconducting (LTS) pulse coil has been (promoted) fabricated. The advantages over the conventional system are easy handling, excellent safety and cost performance.The conduction-cooled LTS pulse coil was successfully developed and demonstrated its stable performance.

To apply the conduction cooled NbTi coil to the SMES, there are several concerns regarding its operation compared with conventional coils such as, stabilities under the steady state operation and the transient disturbance caused by instateneous voltage drop. However, to prove its feasibility, we fabricated a prototype of a 100 KJ class coil, before fabricating the one of 1 MJ class.



a) Winding a layer of conduction cooled coil.

b) Setting DFR P spacers and Litz wires .

Fig. 1 Structure of conduction-cooled LTS pulse coil wires

Spring, 2005 Date of Issue: April 15, 2005
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The coil was wound with a circular cross sectional high specific heat conductor, consisting of an NbTi compacted strand cable extruded with low purity aluminum. The conductor was wound while twisted along with the direction of the coil's magnetic field, reducing the AC loss. The prototype 100 kJ class conduction-cooled LTS pulse coil retained the structure of a GFRP frame and used a coiling wire of NbTi/Cu formed strands. They had an outer diameter of 5.9 mm, coated in a circular cross sectional aluminum through Kapton tape acting as electrical insulation. The coil has a total of 67 turns x 14 layers while twisting the conductor, thus forming a coil section 303 mm in the inner diameter, 516 mm in the outer diameter, and 409 m in length. Figure 1 shows the inner structure of the coil. Once the initial winding layer is complete, a spacer made of Dyneema FRP (DFRP) and a Litz wire (textured copper with insulated base wires) are alternately inserted between layers in the circumferential direction. The DFRP spacer includes a semi-circular groove at each edge corresponding to the position of conductor having completed its winding and to the position of the conductor having been wound in the succeeding respective step. The positioning of the conductor, including the interlayer bridge section and the electromagnetic support, are ensured by adjusting the grooves with corresponding angles for the next layer. The heat flow through the longitudinal direction of the coil is secured by Litz wires. The wire is withdrawn from the coil edge to connect with the second stage of a small cryocooler, thereby enabling the conduction cooling process of the coil. Figure 2 shows the structure of the cooling and excitation test apparatus. Two GM cryocoolers are applied to generate 3 W of cooling capacity at 4K and 120 W at 50K, respectively. Through the Litz wire withdrawn from the coil edge, the coil is conductively cooled to 4K, while the low and high temperature ends of the high temperature superconducting current lead, accepting a rated current of 1000 A, are also cooled by conduction.

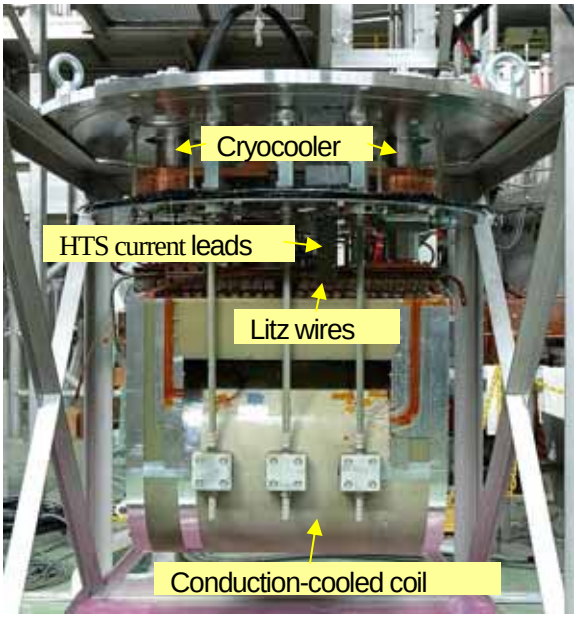

Fig. 2 Cooling and excitation test apparatus for conduction cooling LTS pulse coil

Table 1 shows the result of the cooling and excitation tests.

The developed conduction cooling LTS pulse coil is applicable not only to the SMES for compensating for instantaneous voltage drops but also to various uses of the superconducting coil which require pulse excitation. Accordingly, the extended applications are likely to open up for the previously limited usage of the superconducting coil.

Spring, 2005 Date of Issue: April 15, 2005
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Table 1 Result of cooling and excitation tests of 100 KJ class prototype coil

Test item	Test method, description	Test result	Effect
Cooling test	Indirect cooling from room temperature to 130K by liquid nitrogen. Conduction cooling from 130K by GM cryo-cooler.	Cooling to 4K was made possible within as short a time as 3 days only (1 day for liquid nitrogen cooling, and 2 further days for cooling using a GM cryo-cooler).	Uniform cooling without inducing a temperature gradient in the coil is available. The excellent thermal characteristics of the conduction cooling coil were verified.
Rated current test	One hour of holding operation at a rated current of 1,000 A.	The coil temperature rose by 0.1K owing to the slow temperature rise of the cryo-cooler. The temperature difference between the coil and the cryo-cooler remained unchanged.	Stable continuous operation at rated current was verified.
Overcurrent test	Trapezoidal waveform excitation at an overcurrent of 1,230 A (150 KJ of stored energy).	A stable power throughput was attained at 1,230 A for 5 min.	High stability of coil under overcurrent conditions was confirmed.
High speed shut-off test	High speed shut-off test at coil current of 1,230 A with a shut-off time constant of 1.37 sec (the demagnetization speed was twice this figure for discharge of rated 1 sec).	No normal conducting section is generated. The temperature rise in the coil was limited to only about 0.8K. The presence of a very high thermal conduction characteristic within the coil was confirmed.	The possibility of one-second discharge action for a commercial apparatus was verified with a sufficient margin.
Repeated high speed excitation test	Repeated excitation of a triangular waveform with the peak current of 1,000 A at an excitation-demagnetization rate of 50 A/s.	Even after 20 cycles of repeated excitations, the temperature rise in the coil was confined to 1.1K or less, thus confirmation a positive heat release performance.	Availability of continuous pulse operation of the conduction cooling coil was verified.

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Feature Articles: Superconducting Magnetic Energy Storage (SMES)

- Development of Oxide SMES for bridging Instantaneous Voltage Drops at Chubu Electric Power Co., Inc. -

Naoki Hirano
Superconductivity and New Materials Team
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Chubu Electric Power Co., Inc.

Chubu Electric Power Co., Inc. implements the development of coils of oxide SMES using Bi2212 superconductors. Thanks to its advantageous high current characteristics, critical temperature, and wide temperature margin within a strong magnetic field, Bi2212 oxide superconductors achieve a compact design and high temperature stability alongside a high magnetic field, something which cannot be realized in metal-based materials. Moreover, they also retain satisfactory coil insulatory properties. We fabricated a solenoid coil using a stranded conductor made of six round wires of Bi2212, and confirmed the high insulation performance. Subsequently, we have developed a 1 MVA class SMES coil for bridging instantaneous voltage drops; using a primary strand of Bi2212 500 m in length, and with a 2,500 A class current capacity.

The 1 MVA class SMES coil for bridging instantaneous voltage drops is fabricated by winding a conductor of (1+6) strands of six φ1 Bi2212 wires around a φ1 nichrome wire in the form of short solenoid coils, following which they are subject to an 18 layer lamination while sandwiching an aluminum heat transfer sheet between individual element coils. The short solenoid lamination has the advantages of facilitating coil fabrication with the same length of conductor, making it easy to arrange the coil conducting sheets between laminated coils, and allowing freedom to vary the order of coil laminations in response to the intramagnetic field characteristics of the conductor. Figure 1 shows the appearance of the coil while Table 1 shows the coil specifications.

Fig. 1 1 MVA class SMES coil for bridging instantaneous voltage drops

Table 1 Specification of 1 MVA class SEMS coil for bridging instantaneous voltage drops

Coil form	Laminated single solenoid coil
Coil size	0.38(ID)×0.70(OD)×0.554(H) m
Coil winding number	6 x 49 x 18 laminates
Rated current	500A
Rated voltage	2500V
Inductance	7.87H
Stored energy	984kJ

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The developed coil was integrated with the 1 MVA SMES system to ensure compensation for any instantaneous voltage drops during conduction cooling operations, (Fig. 2). The compensatory action in response to instantaneous voltage drops was tested with a 1 MW simulated load resistance and successive compensatory actions verified to confirm the capability to respond more than once in quick succession, a required quality for equipment designed to compensate for instantaneous drops in voltage. These tests confirmed the effectiveness of actions to compensate for instantaneous voltage drops, and moreover confirmed that the coil temperature did not exceed the designated limit, even in the event of successive compensatory actions and a shut-off action representing the severest form of condition to the coil. Accordingly, the utility of the oxide SMES coil was validated.

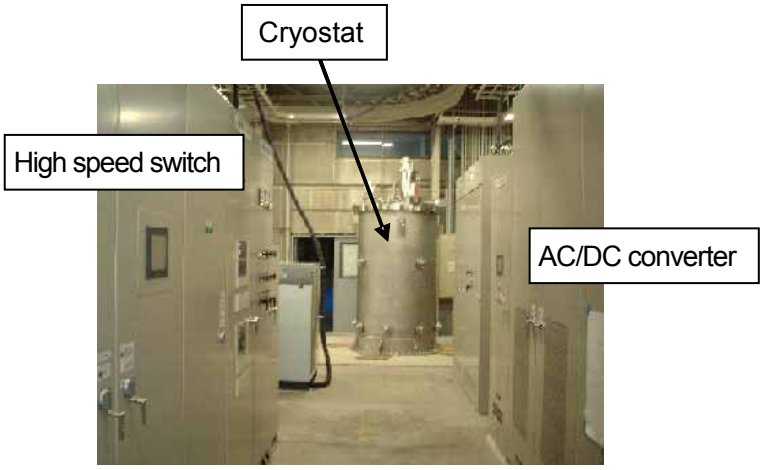

Fig. 2 1 MVA class SMES system for bridging instantaneous voltage drops

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Superconductivity Web21
Published by International Superconductivity Technology Center
5-34-3, Shimbashi, Minato-ku, Tokyo 105-0004, Japan Tel: 03-3431-4002, Fax: 03-3431-4044

Patent Information

Introduction of Published Unexamined Patents in the 3rd Quarter of Fiscal 2004

The following are ISTEC's patents published from October through December 2004. For more information, access the homepage of the Patent Office of Japan and visit the Industrial Property Digital Library (IPDL).

1) Publication No. 2004-289529: "Superconducting Single Flux Quantum Sinc Filter"

This invention provides a superconducting single flux quantum higher-order sinc filter, capable of being implemented in a narrow area and suitable for use in a high speed processing circuits such as A/D converter. The important point of the invention involves placing a multiple-integral type sinc filter with a high speed operation for the front stage, despite its large cell area, and placing a multi-stage decimation type sinc filter for the next stage, occupying a small cell area, despite the inferior operating speed. The configuration allows the superconducting single flux quantum sinc filter with an order of 2 or more and a decimation parameter of 4 or more to be implemented on a chip of about 10 x 10 mm^2 in size.

2) Publication No. 2004-296969: "High Temperature Superconductive Device and Its Manufacturing Method"

The design of a single flux quantum (SFQ) circuit requires that the superconducting loop containing a junction must be so designed the product value of the loop inductance L and the critical current Ic of the Josephson junction as to be less than the 1-flux quantum Φ_0. To minimize the influence of the parasitic inductance of the loop, it is usually adopted to design junctions having small critical current density as well as relatively wide width. The result, however, does not make the best use of the inherent characteristics of high speed operating with the high temperature oxide superconducting junction. With this in mind, this invention constructs two kinds of ramp-edge Josephson junctions with differing critical current densities on a substrate. Accordingly, high Jc junctions for a high speed and high accuracy circuit block, and low Jc junctions for a circuit block with severe restriction of LxIc product are respectively selected. This invention also discloses the manufacturing method of different critical current junctions. This invention not only solves the above parasitic inductance problems to easily realize a high speed superconducting circuit but also allows the less jitter SFQ pulse to form, thereby improving the stable actions of the circuit.

3) Publication No. 2004-303820: "Superconducting Circuits"

For a single flux quantum (SFQ) integrated circuit using a high temperature superconductor, latch driver function is an important elemental circuits as interface circuits to convert the pulse logic of the SFQ circuits to the level logic. Since the high temperature superconducting junction includes a sufficiently small hysteresis in the current-voltage characteristics, it is suitable for high speed pulse logic. However, the high temperature superconducting junction is unsuitable for the latch driver circuits requiring large hysteresis. The invention allows the coexistence of both circuits by realizing two kinds of junctions applying specifically designed junction materials, or by implementing small hysteresis junctions for the pulse logic circuits and large hysteresis junctions for the interface circuits. In concrete terms, the former junction includes a surface-damaged junction barrier layer of the lower superconducting electrode, while the latter junction includes a barrier layer of a very thin deposited insulation layer on the surface-damaged lower superconducting electrode. In turn, the latter junction leads to a large hysteresis and capacitive junction.

Spring, 2005 Date of Issue: April 15, 2005
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4) Publication No. 2004-307256: "MgB_2-based Superconductor with High Critical Current Density and High Irreversible Magnetic Field"

The invention relates to a MgB_2-based superconductor with high superconductivity characteristics. Mg, B, and element M (M is at least one of Ti, Zr, and Hf) are mixed together at atom ratios of Mg:B:M = 1:2:X ($0.001 \leq X \leq 0.1$). The mixture is molded and calcinated to obtain a MgB_2-based superconductor. The superconductor thus obtained contains the M in the form of metal and/or a boride finely disperses along the MgB_2 grain boundaries. The addition of M refines the MgB_2 grains. Furthermore, the metal and/or the boride of element M finely dispersed along the MgB_2 grain boundaries acts as the pinning center, which increases the critical current density under zero-magnetic filed to 5×10^5 A/cm^2 or more, and increases the irreversible magnetic field to 4.5 Tesla.

5) Publication No. 2004-339013: "Oxide Superconductor and Its Manufacturing Method"

Although the increase in the critical density of RE123 series oxide bulk superconductors has become significant, the critical current density at the liquid nitrogen temperature (77K) will remain there for several tens of thousand A/cm^2 level. The invention discloses a bulk superconductor with improved critical current densities ranging from hundreds of thousands A/cm^2 or more at the liquid nitrogen temperature (77K), and the manufacturing method thereof. The RE element in the RE-Ba-Cu-O superconducting materials is prepared by mixing a element (LRE) selected from the group of those having a relatively small ion radius, Gd, Eu, Sm, and Nd, with a element (HRE) selected from the group of elements having a relatively large ion radius, Yb, Er, Ho, Y, and Dy. One of the starting materials to form the precursor is selected as a very fine HRE211 (at least 1 μm or smaller size). With this procedure, a bulk superconductor containing dispersed and very fine (several hundreds of nm) RE211 particles or RE422 particles can be obtained and achieved a very high critical current density overriding the prior art.

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(Published in a Japanese version in the February 2005 issue of *Superconductivity Web 21*)

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Standardization Activities

Topics in December
- The 10th IEC/TC90 Superconductivity International Congress 2006 will be held at Kyoto (tentative venue) -

The Japan Technology Committee of the International Electrotechnical Commission IEC/TC90 (Superconductivity), (Chairperson Professor Kozo Osamura of Kyoto University), held the 3rd Japan Technology Committee Meeting for FY2004 on October 26, 2004. The meeting discussed the site of the 10th IEC/TC90 International Congress scheduled in June 2006 in Japan, and tentatively selected Kyoto as the venue.

The IEC/TC90 (Superconductivity), initially planned in 1987, saw its organization officially approved by the IEC Board Meeting in 1989, from which time Japan was accepted as a member of the IEC/TC90 Council. The 1st IEC/TC90 International Congress was held in Tokyo (Asia) in May 1990. Subsequently, the sponsor country of IEC/TC90 International Congress rounded Europe, the U.S., and Asia, and the 10th Congress is now scheduled to be held once again in Asia. At the 9th IEC/TC90 International Congress, held in September 2004, consent for holding the next congress in Japan was obtained. Responding to the consensus, the 3rd Japan Technology Committee Meeting selected Kyoto as the venue for the 10th ITC/TC90 International Congress.

The official decision concerning the site and other details for the 10th IEC/TC90 International Congress will be provided by the IEC Central Office. The details of the congress, meanwhile, will be disclosed following their decision.

(Published in a Japanese version in the December 2004 issue of *Superconductivity Web 21*)

Topics in January
- ISTEC Prepared Database for the Standardization of Superconducting Transmission and Transformation Equipment -

International Superconductivity Technology Center (ISTEC) (President Hiroshi Araki) and the Institute of Electrical Engineers of Japan (President Tadashi Fukao) completed the research project for standardization data related to superconducting power cables, current limiters, and transformers, (having started from May 2004), in December 2004, thus achieving the predetermined objectives.

The research subjects were: the "Research and Development of Fundamental Technologies for Alternate Current Superconducting Power Equipment", a national project comprising a five-year plan from FY2000 to FY2004, implemented by the Engineering Research Association for Superconductive Generation Equipment and Materials as a contractor of the New Energy and Industrial Technology Development Organization (NEDO): and Japanese technologies relating to the superconducting transmission and transformation equipment.

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For the purposes of project implementation, various groups were organized including the superconducting power cable working group, the superconducting limiter working group, and the superconducting transformation equipment group respectively. These working groups respectively prepared the following three kinds of standardization database:
(1) General requirements applicable during testing of alternate current superconducting power cables.
(2) General requirements applicable during testing of alternate current superconducting limiters.
(3) General requirements applicable during testing of superconducting transformation equipment.

Following a detailed review of the project results covering related Japanese technologies, implemented by the Japan Superconductivity Technology Research Committee and the Technology Committee Meeting of Japan IEC/TC90 Superconductivity Committee, the project results will be reported to the International Specialists Committee to establish a consensus for international standardization. The ultimate goal is to reflect the contents within a published paper which conforms to IEC International Standards.

(Published in a Japanese version in the January 2005 issue of *Superconductivity Web 21*)

(Yasuzo Tanaka, Director, Standardization Department, ISTEC)

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