超電導 Web21
Superconductivity

Summer, 2007 Date of Issue: July 17, 2007

Superconductivity Web21

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

Contents:

Top of Superconductivity Web21

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Tel: +81-3-3431-4002 Fax: +81-3-3431-4044
Top of Superconductivity Web21: http://www.istec.or.jp/Web21/index-E.html

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This work was subsidized by Japan Keirin Association through its Promotion funds from KEIRIN RACE.
http://ringring.keirin.go.jp

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Reflecting on 20 Years of High-Temperature Superconductivity

- 20th Anniversary of High Tc Superconductivity 'Woodstock' Session -

Prof. Shoji Tanaka, Director General, SRL

High-temperature superconductivity was discovered at the end of 1986 and immediately had a tremendous impact. In January the following year, YBCO superconducting materials were discovered, and a worldwide fever was ignited when they exceeded the temperature of liquid nitrogen, and from that point on, high-temperature superconductivity became an unstoppable torrent. Amid such developments, the American Institute of Physics hurriedly convened an emergency session on high-temperature superconductivity on March 15 of that year at the Hilton Hotel in New York. Over 1,800 people were packed into a large hall with a 1,000 plus capacity, leaving an additional 2,000 or so people riveted to video monitors set up outside. The session started at 7:30 PM and continued until 3:15 AM the next morning and was comprised of 51 lectures.

I was invited to the session and was the second one to give a report, following Switzerland's K.A. Muller. While I along with several others were given 12 minutes for our lectures, everyone else only received five minutes. The next day, the New York Times reported that is was "The Woodstock of Physics," and that is no doubt how it will be known to future generations. Woodstock was the location of a huge rock festival celebrating love and peace amid the tumultuous year of 1969 when the Vietnam War and the fight for human rights was having a major impact on U.S. society. Some 400,000 people attended the three-day festival, which kicked off on August 15 of that year, and it has since become a legendary event.

The "20th Anniversary of High Tc Superconductivity 'Woodstock' Session" was held on March 5 this year in Denver, Colorado to commemorate the "The Woodstock of Physics" twenty years ago, and I accepted an invitation to attend. The lectures included 10 people connected to the "The Woodstock of Physics," including George Bednorz and C. W. Chu, and they spoke about what they remembered about that legendary session. Once again, Prof. Brian Maple of the University of California was kind enough to preside over the session, just as he did 20 years ago. As I was asked by the organizers to speak about the circumstances in Japan back then, I reported on the situation of the time, including before an after the time, at my research lab. My lecture was the only one to be honored with the title "Franco Rasetti Lecture." This meant that organizers considered it to be by a distinguished physicist.

Lecture day in Denver

What surprised me was according to Bednorz, he and his team obtained a SQUID flux meter and confirmed the Meissner effect in October 1986, while we had first detected the Meissner effect on November 6 that same year, a mere difference of about two weeks. There were a number of influential theorists in attendance, and bold but credible predications were made that superconductivity at room temperature could possibly be achieved in the next six years.

The session was held between 11:15 AM and 1:15 PM to allow anyone to attend during a lunch break. A large hall was selected as the venue and a great number of people were in attendance at the beginning.

Prof. Shoji Tanaka, Director General, SRL giving his lecture at the “20th Anniversary of High Tc Superconductivity 'Woodstock' Session” in the U.S.

Twenty years ago feels like the distance past, yet at the same time, it seems just like yesterday. I truly hope that the enthusiasm of that time is rekindled now that we are once again hearing about promising new superconducting materials.

(Published in a Japanese version in the May 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

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

Power

Zenergy Power plc (April 2, 2007)

Zenergy Power plc's wholly owned subsidiary, SC Power Systems (San Mateo, California) has received a US $500,000 grant from the California Energy Commission (CEC) to install and test a fault current limiter (FCL) in the Californian electricity grid. The FCL will be installed in a grid belonging to Southern California Edison (SCE), California's largest utility. Together, the CEC and SCE will oversee the testing process and are expected to subsequently produce standardized performance guidelines that are likely to become the benchmark of performance criteria for all future FCLs installed in the United States. The FCL incorporates design input from Australian Superconductors and an HTS coil made by Trithor—two other subsidiaries of Zenergy Power. The FCL will represent a scaled-up version of Zenergy Power's previously constructed prototype. Construction, installation and testing should be completed by the end of 2007. The global market for FCLs is estimated at up to US $ 5 billion annually.

Source:
"California Energy Commission grant for the installation of innovative grid stability device"
Zenergy Power plc press release (April 2, 2007)
http://zenergypower.com/pdf/press-en/2007-04-02-California-Energy.pdf

American Superconductor Corporation (April 10, 2007)

Dongfang Steam Turbine Works Corporation (DTC) has contracted Windtec™, a wholly owned subsidiary of American Superconductor Corporation (AMSC), to develop a portfolio of 2.5-MW wind energy systems. Windtec will also provide project management during the assembly and installation of the first prototype. The contract represents AMSC's third multi-million-dollar contract from a Chinese company for the development of wind energy-related products. DTC is one of the top four wind energy system manufacturers in China. Wang Wei Min, vice general manager and chief engineer of DTC, commented, "DTC has built a substantial presence in China's wind power market and is now looking to increase its market share through the production of higher power systems. By working with an innovative organization like AMSC's Windtec, we can begin producing these units quickly and cost effectively." DTC hopes to being producing 2.5-MW wind energy systems by the end of 2009.

Source:
"AMSC Receives Order from Dongfang Steam Turbine Works to Develop and Deploy 2.5 Megawatt Wind Energy Systems"
American Superconductor Corporation press release (April 10, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=983070&highlight

American Superconductor Corporation (April 17, 2007)

American Superconductor Corporation (AMSC) is reporting continued growth in orders for its power electronics solutions for the global wind power market. VRB Power Systems, Inc. (VRB Power; Vancounver, Canada) plans to integrate AMSC's PowerModule™ power converter technology into its unique wind energy storage system. This novel system is expected to increase the uniformity of electricity from wind farms by storing excess wind-generated energy when demand is low and releasing it when the demand exceeds the available wind-generated power. In this manner, the system should increase the supply reliability of wind energy and reduce the cost of reserve requirements from generation plants.

AMSC also reported a new order for a 6-megaVAR D-VAR® reactive compensation product, which will be used to connect the Scottish Hydro Contracting for the Millennium wind farm in Scotland to the local power grid. The Millennium wind farm will be the 26th wind farm worldwide to utilize AMSC's D-VAR solution. AMSC expects to deliver the unit in the second half of calendar 2007.

Source:
"AMSC Receives PowerModule™ Order for VRB Power Systems Wind Energy Storage Device"
American Superconductor Corporation press release (April 17, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=985762&highlight

American Superconductor Corporation (April 19, 2007)

American Superconductor Corporation (AMSC) announced that Doosan Heavy Industries & Construction Co., Ltd. (Doosan, South Korea) and the Korean Electrotechnology Research Institute (KERI) have utilized AMSC's proprietary HTS wire to successfully develop and demonstrate a very compact, high-efficiency superconductor motor for civilian and military applications. The motor incorporates approximately 5000 m of HTS wire and is capable of generating 1,300 horsepower at 3,600 rpm. The system is also significantly smaller, lighter, quieter, and more efficient than traditional motors of the same power rating. Greg Yurek, founder and chief executive officer of AMSC, commented, "HTS rotating machines are now entering the manufacturing phase, creating significant opportunities for AMSC's superconducting wire and coils." Doosan plans to begin production of the motors for military and commercial markets sometime in 2010 – 2011. AMSC estimates that the annual worldwide market for industrial motors with power ratings of 1000 horsepower or higher is over US$ 1 billion.

Source:
"AMSC Wire Instrumental in Successful South Korean Superconductor Motor"
American Superconductor Corporation press release (April 19, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=987314&highlight

American Superconductor Corporation (April 24, 2007)

American Superconductor Corporation (AMSC) has received another order for its D-VAR® reactive compensation product to meet grid interconnection standards for wind farms. AMSC expects to deliver the 4-megaVAR D-VAR system in the second half of calendar 2007. The wind farm is being developed by Ventus Energy Inc. of Toronto, Canada, and will consist of 55 generators with a total capacity of 99 MW when it comes online in the fall of 2008. The installation will represent the 27th wind farm worldwide to utilize AMSC's D-VAR solution.

Source:
"AMSC Announces D-VAR® Order for New Wind Farm on Prince Edward Island, Canada"
American Superconductor Corporation press release (April 24, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=989255&highlight

Zenergy Power plc (April 26, 2007)

Zenergy Power plc (the Group) has announced the conditional placement of 4,285,746 new ordinary shares of 1p each with a number of institutional investors at a price of 140 p per Placing Share, raising a total of £6,000,000 for the group. The proceeds will be used for general working capital purposes, including the acceleration of its ongoing research and development activities within the field of HTS materials. In particular, the proceeds will be used for the work that the Group is conducting in partnership with Converteam SAS to realize a range of highly efficient, lightweight and compact wind generators for the

offshore wind power market. The placing is conditional to the shares being admitted to trading on AIM.
Source:
“Institutional Placing to raise ￡6,000,000”
Zenergy Power plc press release (April 26, 2007)
http://zenergypower.com/pdf/press-en/2007-04-26-Placing-April.pdf

American Superconductor Corporation (May 1, 2007)

American Superconductor Corporation (AMSC) has completed the previously announced acquisition of Power Quality Systems, Inc. The all-stock transaction was valued at approximately US $4.0 million, or approximately 1.3 times PQS sales for calendar year 2006. PQS produces reactive compensation products known as Static VAR Compensators that are based on proprietary thyristor switch technology. The products can be used to enhance the reliability of power transmission and distribution grids and to improve the quality of power for manufacturing operations. Greg Yurek, founder and CEO of AMSC, commented, "The field-proven thyristor switch technology we obtained in this acquisition will save us time and millions of dollars in development costs for a technology that will enhance our reactive compensation product offerings and increase sales to power grid operators and industrial concerns worldwide." AMSC expects to increase sales of PQS's current product line by approximately 67 % to $5 million for the fiscal year ending March 31, 2008.
Source:
“AMSC Completes Acquisition of Power Quality Systems, Inc.”
American Superconductor Corporation press release (May 1, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=993352&highlight

SuperPower (May 2, 2007)

SuperPower has announced that the 30-meter second-generation HTS cable fabricated by Sumitomo Electric Industries Osaka Works (Japan) using nearly 10 km of SuperPower’s 2G HTS wire has been shipped and is now en route to Albany, New York for use in the Albany HTS Cable Project. The cable will be installed into the cable system at National Grid’s North Albany Service Center later this year and will represent the first installment of 2G HTS wire in a live power grid.
Source:
“Shipment of Completed 30-Meter HTS Cable For Installation Into The Albany HTS Cable Project Announced”
SuperPower press release (May 2, 2007)
http://www.superpower-inc.com/News%20_%20Events.aspx?NewsID=106

American Superconductor Corporation and Nexans (May 8 and 9, 2007)

American Superconductor Corporation (AMSC) and Nexans have announced the successful testing of the world’s first power transmission cable made with second-generation HTS wire. The 30-m transmission-voltage cable was assembled by Nexans using AMSC’s proprietary 2G HTS wire and was tested at Nexans high-voltage facility in Hannover, Germany. The cable was successfully operated at 138 kV, transmitting 435 MVA of power – enough electricity to power more than 250,000 homes. The cable’s rating is more than 50% higher than that of conventional cables at the same voltage level.
Source:
“AMSC and Nexans Announce Successful Testing of World’s First Power Transmission Cable Made With 2G HTS Wire”
American Superconductor Corporation press release (May 8, 2007)

http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=996931&highlight
Nexans press release (May 9, 2007)
http://www.nexans.com/eservice/navigation/NavigationPublication.nx?navigationId=142482&publicationId=-9574&CZ=Corporate&language=en

American Superconductor Corporation (May 16, 2007)

American Superconductor Corporation (AMSC) has received two new orders for its D-VAR® voltage regulation solution for use in Australian mining and wind farm operations. A copper-gold mine will receive one of the D-VARs, which will be used to mitigate power fluctuations arising from the mining operations. The D-VAR is scheduled for delivery in the second half of calendar 2007 and will represent AMSC's fourth order for voltage regulation solutions installed in industrial markets. Greg Yurek, founder and CEO of AMSC, commented, "Adoption of our D-VAR solutions in the industrial sector to enhance productivity is in the early stages of what we believe will be a substantial area of growth. We anticipate that sales to industrials in the next 12 months and beyond will add to the revenue growth we are already achieving in the wind and electric utility sectors."

The second D-VAR order is a follow-on order from Suzlon Energy Australia Pty. Ltd. and will be used to meet the standards for the interconnection of an 88.2-MW wind farm to the local power grid. Suzlon previously ordered five D-VAR systems from AMSC in late 2006, with delivery of the units to two other wind farms scheduled for later this year. The D-VARs will provide voltage regulation, power factor correction, and voltage ride-through for the wind farms. Delivery of the most recently ordered system is expected to occur in the second half of calendar 2007.

Source:
"AMSC Receives D-VAR(R) Orders for Australian Mining and Wind Farm Operations"
American Superconductor Corporation press release (May 16, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1002881&highlight

American Superconductor Corporation (May 21, 2007)

American Superconductor Corporation (AMSC) has signed a contract with Consolidated Edison, Inc. (Con Edison) to develop and deploy a new HTS power grid technology – known as "Secure Super Grids" – in Con Edison's power delivery network in New York City. The Secure Super Grid is a system-level solution that will utilize customized HTS wires, HTS power cables, and ancillary controls to deliver more power while suppressing any power surges that may occur. The Secure Super Grids technology will be the first to combine the benefits of high-capacity HTS cables and fault current limiters in one system, providing both space and cost advantages. Overall, the technology should significantly enhance the capacity, security and efficiency of electric power infrastructures in urban and metropolitan areas. The U.S. Department of Homeland Security is expected to invest up to US $25 million in the development of this technology. Jay M. Cohen, the Department of Homeland Security's (DHS) Under Secretary for Science and Technology, commented, "The U.S. power grid is one of our most valuable assets, and we are taking the steps necessary - through the use of our most advanced technologies - to ensure its safety… We have asked AMSC and Consolidated Edison to demonstrate superconductor solutions in New York City that will serve to keep our centers of commerce on line under all conditions - including grid events related to severe weather, accidents or terrorist attacks."

The undertaking is being referred to as "Project Hydra", as multiple paths for electricity flow will be utilized within the city's power grid to ensure system reliability in the event that individual circuits are disrupted. AMSC will act as the prime contractor for the project; it has signed a letter contract with DHS worth $1.7 million, of which the DHS is expected to fund approximately $1.1 million. Con Edison will act as a subcontractor to AMSC. Southwire Company will also be contracted to perform the detailed cable and termination design as well as to manufacture the superconducting cable, using its HTS Triax cable design. The total project cost is estimated to be $39.3 million, of which the DHS is likely to fund up to $25 million. The deployment of the high-capacity, surge suppressing HTS cable system is projected for completion in three years and will occur in two phases: the development and operation of a prototype system (now underway), and the deployment of the first Secure Super Grid system in Con Edison's power grid. Testing of the prototype is targeted for completion by the end of 2008, while the commissioning of the 13 kV HTS cable system is expected in early 2010. Greg Yurek, founder and CEO of AMSC, said, "Project Hydra represents a powerful convergence of the visions of our three organizations: Con Edison's vision for the adoption of superconductor technology to help create its System of the Future for New York City; DHS's vision to tap into advanced energy technologies to enhance grid security; and AMSC's vision to commercialize superconductor technology for the power grid. Not only will this project kick off the deployment of superconductor technology to the benefit of the people and businesses of New York City, it will also demonstrate a new power grid solution that will have broad appeal around the globe."

Source:
"AMSC, Homeland Security Department and Consolidated Edison Commence Project to Protect New York City's Power Grid" and "AMSC Introduces Surge-Suppressing, High-Capacity Superconductor Power Grid Technology"
American Superconductor Corporation press releases (May 21, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1004588&highlight
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1004590&highlight

Zenergy Power plc (May 22, 2007)

Zenergy Power plc (the Group) has completed the construction and successful testing of a groundbreaking HTS induction heater. As anticipated, the induction heater exhibited an energy efficiency level of over 90%, considerably higher than that of conventional induction heaters – which operate at efficiency levels of between 35 – 45 %. This drastic reduction in electricity requirements is particularly significant considering that heating equipment accounts for 1 – 5% of the total annual electricity consumption in some industrialized countries. Dirk Schötz, a Technical Officer with the German Environmental Fund, commented, "It is our belief that the HTS products being developed by Zenergy are capable of having far reaching impacts on current endeavours to reduce global carbon emissions. The exceptional efficiency levels of HTS products represent a fundamental step change in the energy requirements of a number of global industrial processes, and we are very proud to have supported the development of one of the world's first truly commercial HTS products."

The Group's HTS induction heater is now available for sale; initial sales will likely be made to customers from whom the Group has already received clear expressions of interest. From a cost savings perspective, the Group's induction heater – when run at full capacity – is anticipated to yield ongoing cost savings equivalent to its total initial purchase price in as little as 5 years. The present market for induction heaters is estimated to be about € 2 billion annually.

Source:
"Key Development Milestone"
Zenergy Power plc press release (May 22, 2007)
http://zenergypower.com/pdf/press-en/2007-05-22-Induction_Heater.pdf

American Superconductor Corporation (May 24, 2007)

American Superconductor Corporation (AMSC) has reported their fourth quarter and full year financial results for the period ending March 31, 2007. Revenues for the fourth quarter of fiscal 2006 were US $19.1 million, compared with $14.3 million for the same period in the previous fiscal year. The net loss was $11.4 million, compared with $11.0 million for the same period in the previous fiscal year. Revenues for the full fiscal year 2006 were $52.2 million, compared with $50.9 million for the previous fiscal year. The net loss was $34.7 million, compared with $30.9 million for the previous fiscal year. AMSC ended the fourth quarter with $35.3 million in cash, cash equivalents, and short-term investments, compared with $65.7 million as of the same time point in the previous fiscal year. The total backlog of orders and contracts was approximately $80 million, compared with $23.8 million in backlog as of the same time point in the previous fiscal year. AMSC expects to recognize $58 million of this backlog in fiscal 2007, ending March 31, 2008. AMSC also received an additional $10 million worth of new orders and contracts in April and May that will be recognizable as revenue in fiscal 2007. Greg Yurek, founder and chief executive officer, commented, "Our fourth quarter was a period of tremendous progress at AMSC, and the momentum has continued into fiscal 2007. With the recent completion of two acquisitions, a restructuring and realignment of our business units, an influx of new orders and projects, and near-record revenues in the fourth quarter, we have set the stage for strong growth going forward."

Source:
"AMSC Reports Fourth Quarter and Full Fiscal Year Financial Results"
American Superconductor Corporation press release (May 24, 2007)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1006530&highlight

Material

Superconductive Components, Inc. (May 3, 2007)

Superconductive Components, Inc. has announced their first-quarter financial results for the period ending March 31, 2007. Total revenues for the quarter increased by 104% to US$ 2.5 million, compared with $1.2 million for the same period in the previous fiscal year, mainly because of an increase in the sale of photonics/optical and thin film battery products. Gross profit also increased by 68% to approximately $ 0.5 million, compared with $ 0.3 million for the same period in the previous fiscal year. Research and development expenses increased to $63,164, compared with $47,176 for the same period in the previous fiscal year. As of March 31, 2007, the company's backlog was $3.3 million, four times the backlog registered on March 31, 2006.

Source:
"Superconductive Components, Inc. Reports Improved First Quarter 2007 Results"
Superconductor Components, Inc. press release (May 3, 2007)
http://www.sciengineeredmaterials.com/investors/ne/earnings/scci17.htm

NMR

Massachusetts Institute of Technology (May 15, 2007)

Researchers at the Massachusetts Institute of Technology (MIT)'s Center for Bits and Atoms have reported a radically different approach to performing nuclear magnetic resonance (NMR). Their highly sensitive technique utilizes a microscopic detector that effectively reduces the amount of protein required for measurements of molecular structure. The technology has the potential to lead to the proliferation of tabletop-sized NMR devices in research laboratories and medical offices and could prove invaluable for the diagnosis of a variety of diseases, including the detection of glaucoma and cataracts at a stage early enough to enable treatment. The new approach departs from the use of conventional coils and instead is based on guiding waves, similar to the Wi-Fi antenna technology utilized in laptop computers. The MIT group used a laser to make a microscopic slot in a flat strip of metal, known as a strip line. The magnetic field that leaks out of the line creates a uniform, magnetic field and enables the slot to be used as an NMR probe. The detector, which is placed on a plastic card that is about one-third the size of a credit card, is easy and inexpensive to produce. At present, the detector must still be placed in a large machine housing a superconductor magnet, but the researchers anticipate that the microslot's small sample volume should encourage the production of smaller tabletop-sized spectrometers. The small sample size required by the detector could dramatically improve the rate of biomedical research, advancing both drug discovery and the study of biological pathways. The group's results were reported in the May 14 online and print editions of the *Proceedings of the National Academy of Sciences*. The research was funded by the National Science Foundation.

Source:
"NMR advance relies on microscopic detector"
Massachusetts Institute of Technology press release (May 15, 2007)
http://web.mit.edu/newsoffice/2007/microdetector.html

Magnet

Florida State University (April 4, 2007)

Florida State University and the National High Magnetic Field Laboratory (NHMFL) have received a contract from the Hahn-Meitner Institute (HMI; Berlin, Germany) for the construction of a US$ 8.7-million high-field hybrid magnet for use in neutron scattering experiments. The magnet, which will be based on NHMFL's Series-Connected Hybrid concept, will be capable of producing a magnetic field between 25 and 30 Tesla and will be the world's strongest magnet for neutron experiments – far greater than the 15-Tesla system presently installed at HMI. The Series-Connected Hybrid concept combines a copper-coil "resistive" magnet technology on the interior with a superconducting magnet, cooled with liquid helium, on the exterior. The resulting hybrid magnet can produce extremely high magnetic fields while using only one-third of the power required by a comparable conventional magnet. The magnet that will be constructed for HMI will contain a conical bore to enable wide-angle neutron scattering. The bore will also be horizontal, rather than the vertical bore of most high-field magnets. When completed in 2011, the new magnet will be installed at the Berlin Neutron Scattering Center.

Researchers at NHMFL have been working with HMI to develop a design for the magnet since 2005. The development of the new technology required for the magnet will be funded by the German Federal Ministry of Education and Research. In addition to the $8.7 million price tag for the magnet, another $14.4 million will be required for infrastructure, including the cooling and current supplies needed for the magnet's operation.

Source:
"FSU's Magnet Lab to build the world's strongest magnet designed for 'neutron scattering' experiments"
Florida State University press release (April 4, 2007)
http://www.magnet.fsu.edu/mediacenter/news/pressreleases/2007april3.html

Communication

ISCO International, Inc. (May 3, 2007)

ISCO International Inc. has reported their first-quarter financial results for the period ending March 31, 2007. Consolidated net revenues were US$ 1.0 million, compared with $ 1.3 million for the same period in the previous fiscal year. The consolidated net loss was $ 2.4 million, compared with $ 1.7 million for the same period in the previous fiscal year. The gross margin decreased to 26 %, compared with 38 % for the same period in the previous fiscal year. John Thode, CEO of ISCO, commented, "Naturally we are disappointed with our first quarter results, an outcome we worked hard to avoid after similar results in the first quarter of 2006. Though we continue to expand and differentiate our product portfolio and customer base, there remains a good deal of demand volatility in our business segment due to structural changes in the industry. While our strategy is to exploit these discontinuities, we are still impacted by overall demand and spending patterns of our customers." The company does expect demand to grow throughout the year, and their objective for 2007 – to grow their top and bottom line results on a full-year basis – remains the same.

ISCO also presented a product update in which they reported that they have made substantial progress toward the completion of their fully digital filtering platform. Based on customer feedback, they have also begun to evaluate several new horizontal applications for this platform.

Source:
“ISCO International reports financial results for the first quarter 2007, product update and investor call”
ISCO International, Inc. press release (May 3, 2007)
http://www.b2i.us/profiles/investor/ResLibrary.asp?ResLibraryID=19824&f=1&BzID=826&Nav=1&LangID=1&s=0&Category=135

Accelerator

CERN (April 10, 2007)

CERN reported that the first sector of the Large Hadron Collider (LHC) has been successfully cooled to 1.9 K. Although this sector comprises only one-eighth of the entire LHC ring, it nevertheless represents the world’s largest superconducting installation to date. Eventually, all eight sectors of the 27-km ring that comprises the LHC, including 1650 main superconducting magnets for guiding and focusing the proton beams, will be cooled. Each sector of the ring will be cooled using a three-phase process: first, the sector is cooled to 80 K. At this temperature, 90% of the thermal contraction will have occurred; since each sector is about 3.3 km long, this amounts to 9.9 m in shrinkage. The LHC’s equipment has been specifically designed to compensate for this shrinkage. After tests are performed to ensure that no hardware breaks have occurred, the main magnets are filled with liquid helium to enable the second phase of cooling to 4.5 K. Finally, a sophisticated pumping system is used to pressurize the helium and reduce the temperature to 1.9 K. Serge Claudet, head of the Cryogenic Operation Team, remarked: “It's exciting because for more than ten years people have been designing, building and testing each part of this sector separately and now we have a chance to test it all together for the first time.”

Source:
“For the first time the LHC reaches temperatures colder than outer space”
CERN press release (April 10, 2007)

http://press.web.cern.ch/press/PressReleases/Releases2007/PR03.07E.html

CERN (April 26, 2007)

A ceremony was held at CERN to mark the lowering of the last superconducting dipole magnet into the Large Hadron Collider (LHC)'s tunnel, completing the basic installation of the more than 1700 magnets that compose the collider. LHC project leader, Lyn Evans, commented, "More than 35 000 tonnes of material has been safely lowered underground, transported up to 15 km inside the tunnel and positioned with an accuracy of a tenth of a millimeter. It is a fantastic achievement." Once in position, the magnets will be connected to the cryogenic system, which will maintain the entire accelerator at 1.9 K. The LHC is scheduled for commissioning at the end of 2007.

Source:
"Closing the gap: descent of the last LHC magnet"
CERN press release (April 26, 2007)
http://press.web.cern.ch/press/PressReleases/Releases2007/PR05.07E.html

Princeton University (May 30, 2007)

Researchers at Princeton University have developed new imaging techniques that enable superconducting behavior to be visualized at the nanoscale level. Using a specially customized scanning tunneling microscope, the researchers were able to observe tiny, isolated patches of superconductivity within several high-quality ceramic superconductors even after the materials had been warmed to temperatures above their critical temperature. While the overall sample was too warm to exhibit superconductivity, disconnected regions within the sample exhibited Cooper pairs – a phenomenon that was previously thought to occur only at temperatures below a material's critical temperature. Although the patches were only a few nanometers wide, they were observed in some materials at temperatures as high as 50 degrees above the material's critical temperature. Ali Yazdani, senior author of the research paper, speculated that understanding why these patches of superconductivity exist at higher temperatures – and how to create a material that exhibits this property everywhere – may be the key to enhancing superconductivity. The research is reported in the May 31 edition of Nature.

Source:
"Nanoscale imaging reveals unexpected behaviors in high-temperature superconductors"
Princeton University press release (May 30, 2007)
http://www.princeton.edu/main/news/archive/S18/01/00O69/index.xml?section=newsreleases

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

(Published in a Japanese version in the July 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

Superconductivity

Superconductivity Web21

Published by International Superconductivity Technology Center
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Feature Articles: Superconducting Industry - Transport Equipment Technology - Non-contact Liquid Mixing Technology Using Bulk Superconductors-

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With the advancement of medical and biotechnology, ultra pure environments are desired when chemicals are mixed together. Non-contact mixing is effective in improving purity. Equipment that uses superconductivity to perform non-contact mixing is already being devised. The superconducting mixer we developed this time employs a method that uses a pinning effect to raise and then rotate both a superconducting bulk and magnets with stirring blades in a stable state. This makes non-contact mixing possible within an airtight container, resulting in the ability to mix solutions in ultra clean environments.

Figure 1 is a schematic diagram of the mixer we developed. This mixer utilizes non-contact magnetic coupling between a superconductor and permanent magnets. It consists of three major components: (1) Lower magnetic circuit that connects with a driving motor and transfers rotational torque to the mixer; (2) Bulk superconductor that is housed in a liquid nitrogen cryostat located outside the mixer and transmits rotational torque; (3) Upper magnetic circuit with rotor blades for mixing the liquid in a mixing container.

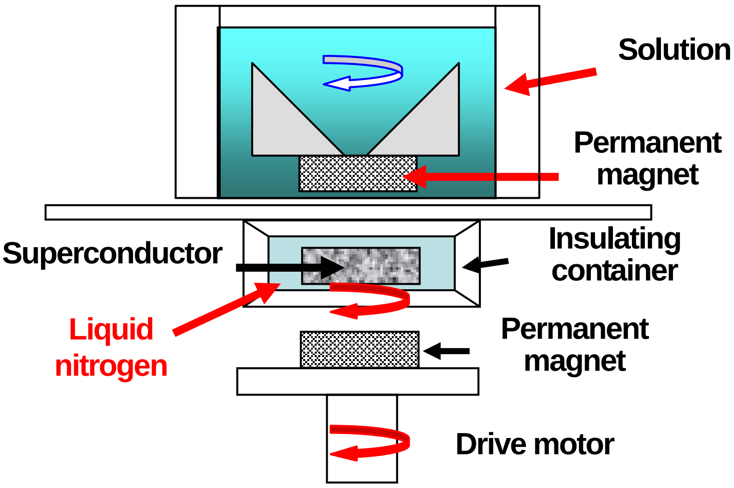

Fig. 1 Newly developed superconducting mixer

The actual mixing process is carried out as follows. First, the bulk superconductor is placed at the bottom of the cryostat. When doing so, the lower magnetic circuit and upper magnetic circuit are fixed in place so that they will stay at a fixed distance. In this state, the liquid nitrogen will cool the superconductor. This cooling results in magnetic coupling by the pinning effect between the upper and lower magnets and the superconductor. In this state, using the motor to rotate the lower magnet causes the superconductor and upper magnet to rotate in conjunction, thereby making it possible to mix the solution.

The magnetic circuits are comprised of north and south poles alternately embedded along the outer frame of a stainless container with a diameter of approximately 100 mm. The purpose of this is to transmit rotational torque by means of the pinning effect. The superconductors have diameters of 110 and 140 mm and are made of Gd-Ba-Cu-O. Torque is 300 Ncm when the superconductors and the magnetic circuits are 15 mm apart, although this depends on the initial gap. 100 Ncm is required for mixing 30 L of solution, and a value at a practical level is being achieved. We now plan to build an actual prototype and evaluating its performance.

(Published in a Japanese version in the March 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

Superconductivity Web21

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Feature Articles: Superconducting Industry - Transport Equipment Technology - Multipurpose Magnetic Separation Technology Using Bulk Superconducting Magnets -

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1. Introduction

Our research group has thus far developed a variety of magnetic seeding processes for materials (for example fine particles, oil droplets, fibrous materials, and microorganisms) suspended in aqueous solutions and soluble substances (such as ammonia nitrogen and phosphorus), and by combining a variety of magnetic separation systems, we have developed a system that can treat wastewater at a practical level. However, there is a much more need for small volume treatment systems that can handle the wastewater from a variety of products, than for large volume treatment systems, and we have received numerous requests to develop new applications in the biotechnology and medical fields. In response, we studied the potential of magnetic separation by bulk superconducting magnets because a system that uses such magnets could even be made portable if it could be designed in a relatively compact manner. This article introduces the potential applications we identified for many different fields.

2. Preprocessing Method for Versatility in Magnetic Separation: Magnetic Seeding

Magnetic separation is a process in which a magnetic field is used to separate/collect certain substances or materials, such as pollutants or organic matter, from a liquid. When the materials to be separated or collected do not have ferromagnetism (for example, paramagnetic or diamagnetic materials), it is difficult to separate them from a liquid using a magnetic field from a normal permanent magnet. Although superconducting magnets can be used to separate paramagnetic or diamagnetic materials, it is not a very sustainable process when cost is factored in. And it is even less feasible economically when applied to the treatment of wastewater. However, if it were possible to make ferromagnetic particles adhere to paramagnetic or diamagnetic materials (a process known as magnetic seeding), magnetic separation technology could be applied to the separation/recovery of a wide variety of materials, and we could build systems that were economically sustainable.

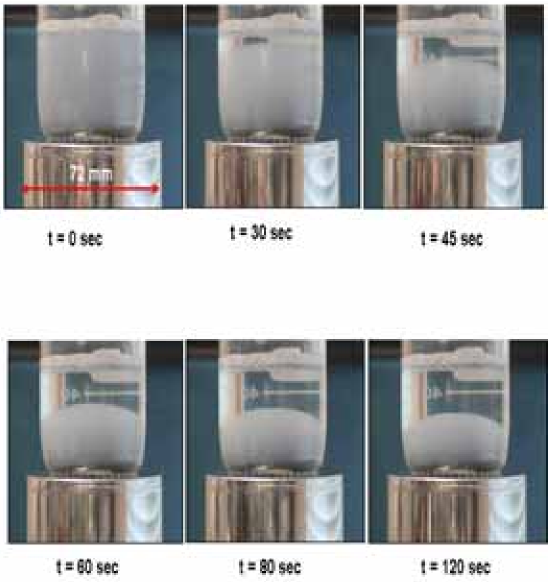

Fig. 1 Photograph of a series of separation process with time after applying the magnetic force using bulk superconducting magnet.

3. Model Test

We prepared a magnetic-seeded sample solution using ferromagnetic particles and a flocculant in an

O/W emulsion in which oil droplets were dispersed, moved it to a glass container, and then placed the container on a bulk superconducting magnet (GdBaCuO bulk superconducting magnet), as shown in the photo in Fig. 1. This resulted in the magnetic flock comprised of the emulsion and magnetic particles quickly precipitating in about one minute. This shows that magnetic attraction can be moved from the surface of the magnet to a position several centimeters away by using a bulk superconducting magnet. It also shows that separation at speeds not possible with permanent magnets can be achieved.

4. Design Method for a Magnetic Separation System

The driving force for the magnetic separation method is magnetic attraction applied to the substance to be separated. In general, magnetic force F_M is expressed by formula (1) below. In this formula, b is the radius of magnetic particles, μ_0 is permeability in vacuum, χ_p and χ_f are the magnetic susceptibilities of the particles and medium, respectively, H is the strength of the magnetic field, and ∇H is the magnetic gradient.

$$\begin{aligned} \mathrm{F_M} &= 4/3\pi b^3 \mu_0(\chi_p - \chi_f)H \cdot \nabla H \\ &\cong 4/3\pi b^3 Ms\ \nabla H \end{aligned} \tag{1}$$

$$\mathrm{F_D} = 6\pi b\,\eta\left(v_f - v_p\right) \tag{2}$$

$$v_p = v_f - \frac{2b^2 \mathrm{\mu}_0 \chi H \nabla H}{9\eta} \tag{3}$$

The final term is the product of the volume, saturation magnetization (Ms), and magnetic gradient. It assumes that the magnetization of the ferromagnetic particles is thoroughly saturated. The outer magnetic field in which magnetization is saturated is between about 0.3 and 0.5 T, so it is an approximated term for when an external field of that strength or higher is realized. On the other hand, the drag force F_D (the force from a fluid that attempts to push the material to be separated within the fluid) that resists magnetic force is expressed by formula (2). In this formula, V_f and V_p are the fluid velocity and the particle velocity, respectively, and η is the fluid viscosity. Performing magnetic separation requires that magnetic force F_M exceeds drag force F_D ($F_M > F_D$). If we solve this equation system with V_p, the condition that must be satisfied magnetically is found. This is shown in formula (3). The second term on the right side of this formula is called magnetic velocity, and it brings together the magnetic substances that have a velocity dimension. Designing this magnetic velocity is the same as designing a magnetic separation system. We can also say the purpose of the magnetic seeding process is to increase this magnetic velocity. For example, if we wanted to increase the processing rate, we would need a device that could generate a strong magnetic field, such as a superconducting magnet. However, since the higher the magnetic gradient goes, the larger the magnetic attraction force will be, as was made clear by formula (1), we must also consider a system that generates a high gradient magnetic field to ensure the success of magnetic separation. This includes not only the characteristics of the magnet, but also the placement of thin ferromagnetic wires within the magnetic field.

5. Conclusion

Our research group has been conducting fundamental research on magnetic separation since 1997 or thereabout, and our development of a practical wastewater treatment facility for papermaking with support from NEDO has made a name for ourselves through exhibitions, academic conferences, and other events not only in Japan, but in Asia and Europe as well. That prompted us to establish a Consortium for Magnetic Control Technology (tentative name) to not only exchange information concerning magnetic separation technology and disseminate system theories and technical information, but also create commercial opportunities for magnetic separation technology that can be applied to environmental fields and biotechnology. We aim to become a joint research and development organization that can collaborate with the various enterprise groups that have developed an interest in this technology. We truly hope that it will grow as a major field of superconductive engineering.

(Published in a Japanese version in the March 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007
Superconductivity Web21
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Feature Articles: Superconducting Industry - Transport Equipment Technology - Fermentation Technology for Japanese Sake Mash in a Strong Magnetic Field -

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Kyushu Institute of Technology

Using a cryocooled superconducting magnet, it is now possible to apply a strong magnetic field of 10 T to a room-temperature space over a long period of time. This makes possible applications that were not practical up until now. One such application has an impact on living organisms. The impact of magnetic fields on organisms such as tadpoles, Japanese killifish, and round worms, has already been studied, but there always seems to be a problem in terms of reproducibility in each and every case. With microorganisms on the other hand, it is possible to apply a magnetic field to countless individual organisms at once, and since there is little time between generations, the likelihood of confirming the impact is much higher. Our group decided to study what sort of difference in taste would arise when a magnetic field was applied to yeast while brewing Japanese sake. Since sake is an extremely delicate brew, there is the potential for major differences to arise. Furthermore, sensory evaluation (sake tasting) by the human mouth is very sensitive and thus able to detect even the subtlest differences.

Since the sake manufacturing process is rather complex, we decided to prepare some koji (aspergillus oryzae, the mold used in the brewing process) extract and make some sake mash. Koji extract is made by rice and malted rice that has been mixed together and saccharified. We had the Fukuoka Industrial Technology Center prepare the koji extract for our experiment. Koji extract has an amber color and is sweet tasting. We put yeast for making refined sake directly into it. Yeast converts glucose into alcohol through fermentation. The temperature of the koji extract into which we placed the yeast was maintained at 15 ºC and a magnetic field of 10 T was applied. We also prepared a sample that was not subjected to a magnetic field for comparative purposes. The taste test was performed by an alcoholic beverage appraiser from the Fukuoka Regional Taxation Bureau. The taster noted that the sample exposed to the magnetic field clearly had a sweeter taste. In addition, quantitative analysis on the chemical composition revealed that the sample exposed to the magnetic field had slightly more glucose and less alcohol. Furthermore, the sample exposed to the magnetic field had less number of yeast. Based on this, we can conclude that applying a magnetic field suppresses yeast activity. In short, the suppression of yeast activity hampered the conversion of glucose into alcohol, resulting in a sweeter taste. We are now in the process of confirming this by time-course measurements of yeast quantity, but we believe we have verified the reproducibility of this experiment because we have achieved the same results under a variety of conditions.

We do not yet know why applying a magnetic field suppresses yeast activity, but we can surmise that there was metabolic effect, based on the fact that oxygen has magnetic properties and the ingredients we were working with contained iron.

Until now, the only way to suppress yeast activity in sake brewing was to lower the temperature. Premium Ginjo sake is brewed slowly at a low temperature of 10 °C rather than 25 °C at which yeast activity is at its highest. By using magnetic fields to control yeast activity, it would be possible to produce flavors that were never before possible.

This research was conducted jointly with Kyushu Electric Power Co., Inc.

(Published in a Japanese version in the March 2007 issue of Superconductivity Web 21)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

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Feature Articles: Superconducting Industry - Transport Equipment Technology - Developments in Superconducting Traction Transformers for Rolling Stock -

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Railway Technical Research Institute

The traction transformers installed on Japan's bullet trains(shinkansen) as well as AC and AC/DC-powered rolling stock are crucial equipment for supplying electric power received from overhead contact line to auxiliary circuits, including the main circuit that drives the rolling stock and the air-conditioning system. However, they are also the heaviest of all the equipment installed, and there is a great demand for their weight to be reduced. The lightening of rolling stock is also an important topic in terms of increasing the speed of high-speed trains and reducing the energy they consume, as well as reducing the load on equipment on the ground. In light of this, trimming the weight of transformers is a crucial area of R&D. By switching to aluminum coils and lightening various components, the weight to capacity ratio on bullet train transformers has been reduced from the initial (0 Series) level of 2 kg/kVA to the recent (700 Series) 0.74 kg/kVA, which is nearly 1/3 the original level, but we believe that switching to superconducting windings will achieve further gains in weight reduction and efficiency.[1]

Superconductivity research conducted at the Railway Technical Research Institute (RTRI) looked into the use of metallic superconducting wire in the early 1990's, but all it found were major disadvantages, such as high AC loss and the need for heavy cryocooling equipment.[2] However, advances in high-temperature superconducting wire spurred superconducting traction transformer R&D in Japan and Germany in the later half of the 1990's.

With the cooperation of Kyushu University, Fuji Electric Systems, and Taiyo Nippon Sanso, RTRI kicked off superconducting transformer R&D in the later half of the 1990's using Bi superconducting wire. The goal was to develop transformers that could be installed on bullet trains. Design optimization for reducing the weight of a superconducting transformer with the specifications shown in Table 1 resulted in high AC loss when using conventional high-temperature superconducting wire, and even if increased efficiency could be expected, the resulting weight exceeded 4 t, which was heavier than existing

Table 1 Specifications of superconducting traction transformer for 4 MVA railway rolling stock

Primary winding	4 MVA, 25 kV, 160 A
Secondary winding	3.6 MVA, 1.2 kV x 4 windings, 750 A
Tertiary winding	400 kVA, 440 V, 909 A
% impedance	Same level (about 20 %) at present
Reactance matrix	Same level at present (diagonal element of about 0.8 mH and a non-diagonal element of about 0.1 mH or lower)
Testing method	According to the JIS test method for traction transformers for rolling stock. The short circuit duration of the secondary winding was 0.1 seconds.
Installation location	Floor

transformers. However, it is clear that if we assume that the AC loss could be reduced to 1/5 the current level, which is near the theoretical value, we could expect over 99 % efficiency and a 20 % weight reduction to 2.4 t over existing transformers.[1] Based on our design study results, we built a prototype full-size floor-mounted superconducting traction transformer (Fig. 1) in 2004. To verify its electrical characteristics, we are conducting an assessment test conforming to the test format of JIS E 5007 “Railway rolling stock -Traction transformers - Test methods” and a traction circuit combination test and vibration test simulating its installation on railway rolling stock. We are also verifying design validity, including ensuring that the capacity is equivalent to 3.5 MVA, estimating mass, and checking insulating characteristics.[3] However, there are also several issues, including low capacity and high AC loss due to superconducting wire characteristics that were lower than what was assumed during the design phase, and a limited running time due to low cryocooler cooling capacity. In an effort to develop a practical model, we are attempting to lower AC loss and design a 1 kW-class cryocooler.


Fig.1 Full-size floor-mounted superconducting traction transformer

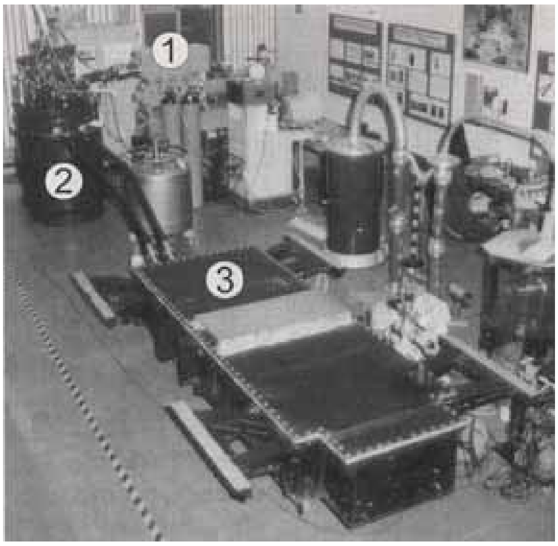

Fig. 2 Prototype 1 MVA superconducting traction transformer built by Siemens AG

Germany and a number of other countries have adopted a 16.7 Hz railway electrification system with transformers that are larger and heavier than the commercial frequency variety. Germany’s Siemens AG starting developing superconducting traction transformers under such circumstances, beginning with a small 100 kVA prototype. In 1999, the company started developing a 1 MVA prototype and running a variety of characteristic tests, including load loss and no-load loss tests at 50 Hz and 16.7 Hz, as well as connection tests with converters to simulate actual operation (Fig. 2). They had then planned on manufacturing a full-size prototype that could handle several MVAs, but it seems that development is currently suspended.[4, 5]

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(Published in a Japanese version in the March 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

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Feature Articles: Superconducting Industry - Transport Equipment Technology

- Developments in Superconducting Squirrel-Cage Induction/Synchronous Motors -

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In recent years, a variety of electric power equipment applying high temperature superconductivity (HTS) has been under study amid the remarkable developments being made in HTS materials. In particular, vigorous R&D is underway on HTS synchronous motors that run at higher temperatures of 20 K or above, and there are high hopes for increasingly high power densities and size/weight reduction with the dramatic improvements being made in electric loading and magnetic loading.

Meanwhile, if we take a look at conventional (normal conducting) motors, we find that despite there being difficulties in terms of efficiency and speed control, induction motors (in particular, squirrel-cage induction motors) are widely used due to their simple construction, ease of maintenance, low cost, and availability of mass production. From the user's perspective, it is clear that the aforementioned advantages are important amid the long development history of motors. In response, my research lab has been busy showing, both theoretically and experimentally, that it is possible to not only harness the advantage of induction machines while getting the increased performance that comes with switching to superconduction (size/weight reduction, increase power density, high starting and acceleration torques), but also implement new functionality that surpasses conventional motors (compatibility of induction and synchronous operation, increased efficiency from synchronous operation, drooping speed characteristic with almost constant torque, and robust controllability of overloading).

As far as I am aware, Sim et al. (Soonchunhyang University, South Korea) were the first to experimentally study the fundamentals of switching to superconducting induction motors, and they were able to confirm the existence of synchronous torque.[1] Unfortunately, its seems that their group is no longer conducting research. Recently, T. Ishigohka (Seikei University) et al. started experimental research on the topic.[2] In addition, a look at patent applications reveals that a structure where HTS wire rod is inserted inside a hollow-shaped normal conduction rotor bar and end ring is being proposed.[3] This structure suggests the potential for achieving the synchronous torque that accompanies flux trapping using the "normal conduction to superconduction (zero resistance)" state transition after starting the motor at or above the HTS critical temperature and then setting temperature lower than that once it is up to a certain level of speed. However, achieving the aforementioned state transition requires the changing of secondary winding temperature in order to transit from slip to synchronous operation, and this is not thought to be practical at the present time. Furthermore, since the resistance of the normal conduction rotor bar is being used to start the motor, there seems like double squirrel-cage characteristics.

Since my group is using the "flux flow to zero resistance" state transition (no transition to normal conduction state) in an HTS material, there is no need for the aforementioned temperature control and so on. Another feature is the ability of the process from startup to acceleration to synchronization to be automatically implemented thanks to the non-linear current transport characteristics of HTS wire.[4] In addition, this motor is based on synchronous steady operation, but it is possible to implement motors resistant to hunting and step out. Specifically, we have experimentally confirmed that even when applying a load exceeding maximum synchronous torque during synchronous operation, transition to slip mode and operation at nearly constant torque is possible, and if the load is removed, then transition to synchronous operation will be quick (we are verifying that some load characteristics can be quantitatively described based on non-linear equivalent circuit analysis).[5] Furthermore, so-called armature reaction does not occur and there is no need for independent power supplies for field~~s~~ winding. Figure 1 is a photo of the prototype HTS squirrel-cage rotor that my group built. We refer to this motor as an HTS induction-synchronous motor (HTS-ISM). We hope that the community developing this motor will expand in the future.

Fig. 1 Prototype HTS squirrel cage rotor

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(Published in a Japanese version in the March 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

超電導 Web21
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Summer, 2007 Date of Issue: July 17, 2007

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Feature Articles: Superconducting Industry - Transport Equipment Technology - Prospects for Electric Propulsion Ships -

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The demand for improved efficiency (better fuel economy) in automobiles and other transportation equipment is growing ever stronger in recent years due to the heightening concern about global warming and skyrocketing crude oil prices fueled by resource nationalism. In particular, electrically driven vehicles, such as hybrid cars, electric vehicles, and fuel cell vehicles, are attracting attention, the most common example being the Toyota Prius.

There are also similar movements in the shipping world, including CO_2 emission reductions to conform to COP3 and NOX regulations set forth by the International Maritime Organization (IMO), and this is heightening the interest in electric propulsion ships. Electric propulsion systems are being adopted even in the R&D of the Super Eco-Ship Project led by the Ministry of Land, Infrastructure and Transport. The strengths of electric propulsion ships include the following:

(1) Lower NOX emissions by such means as using a four-cycle engine.
(2) Increase in available space due to flexibility in engine room layout.
(3) Reduced noise/vibration.
(4) Improved ship control when combined with POD.

However, they also have the following weaknesses:
(1) Total transmission efficiency, consisting of (power generation efficiency) + (energy conversion efficiency) + (motor efficiency) is about 82 % to 85 %, which is about 10 % to 15 % lower than the transmission efficiency of a diesel engine.
(2) High initial cost.

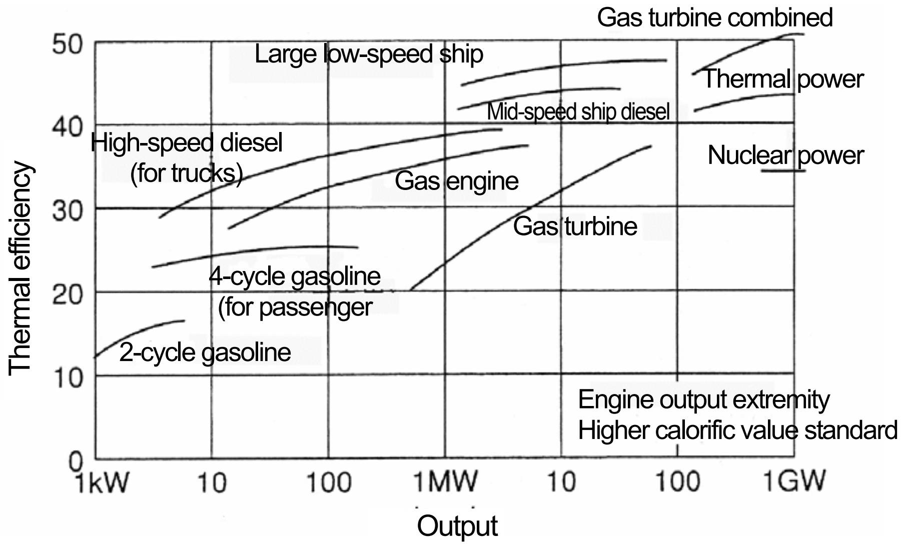

Fig. 1 Thermal efficiency of different types of engines (Source: Mitsubishi Heavy Industries Technical Review, Vol. 34. No. 3)

These weaknesses must be overcome before electric propulsion becomes as widespread in ships as it is now becoming in automobiles. The two-cycle low-speed diesel engines widely used to propel large ships are extremely efficient (see Fig. 1) compared to other types of engines, which means vastly improving propulsion efficiency is essential in replacing conventional diesel-based systems with electric propulsion systems. In response, Mitsubishi Heavy Industries, Ltd. developed a high-speed ferry with the world's first hybrid CRP pod propulsion system (single-screw ship) shown in Fig. 2. This system dramatically reduces resistance and improves propulsion efficiency over two-screw ships and achieves an energy savings of 13 %, despite being electrically propelled. However, such a major improvement cannot be expected on a normal single-screw ship, and as a result, using the flexibility of engine room layout to develop hull forms with dramatically less resistance and improving overall transmission efficiency by raising power generation efficiency and motor efficiency will be indispensable.

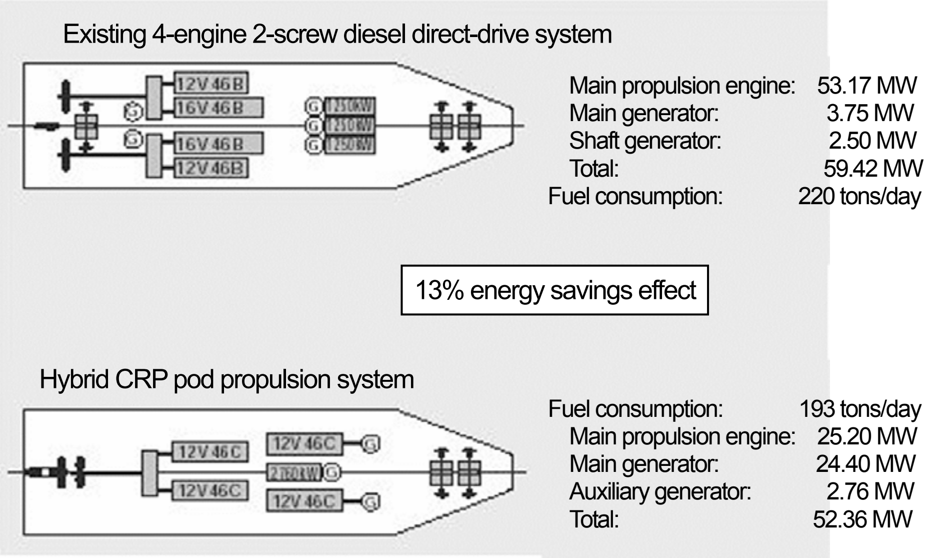

Fig. 2 Comparison of propulsion plants (Source: Mitsubishi Heavy Industries Technical Review, Vol. 41. No. 6)

Compared to automobiles, which repeatedly accelerate rapidly and then stop, efficiency improvements cannot be expected to a great extent by a switch to a hybrid system on ships that, for the most part, travel at a steady speed, but we hope that by using superconductivity, generators and motors can be made smaller and more efficient, and thereby help popularize electric propulsion ships.

(Published in a Japanese version in the March 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

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Feature Articles: Advances in Superconducting Materials Technology

- Advances in Strain Effect Technology for Nb_3Sn Superconducting Wire -

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1. Introduction

We have discovered the pre-bending effect that improves the characteristics of bronze-processed Nb_3Sn superconducting wire through repeated bending strain at room tempeature,[1] and are now carrying out research on elucidating and finding applications for this mechanism. This article introduces the results that have been obtained thus far and the current state of applied research for the prebending effect.

2. Pre-bending Effect

Common Nb_3Sn wire is composite material comprised of Nb_3Sn on the inside and Cu on the outside. However, with this alone, tensile stress of around 150 MPa will cause I_c to irreversibly degrade by up to one half. To improve the mechanical characteristics of such wire, wire reinforced with CuNb, Al_2O_3, Ta, or Cu-NbTi is being developed.[2] Fig. 1 shows a cross section of CuNb-reinforced wire. Heat treating the wire to approximately 700ºC by superconductor reaction and then cooling it generates stress due to the different thermal expansion coefficients of the materials and applies compressive strain to the Nb_3Sn. The fact that this residual strain limits the superconducting characteristics of Nb_3Sn wire to a value lower than its original value is well known. Fig. 2 shows the strain dependence of I_c in CuNb-reinforced Nb_3Sn wire. Strain where I_c is at the maximum is equivalent to residual strain.

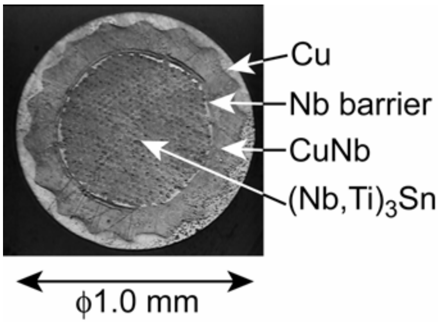

Fig. 1 CuNb-reinforced Nb3Sn wire rod

The principal behind the prebending effect is the relaxation of this residual strain. Alternately applying bending strain repeatedly causes tension to be applied to the outside of the bend and compressive strain to the inside. Stabilizing material on the outside of the wire plastically deforms, but the Nb_3Sn on the inside does not, thereby relaxing the residual strain. Results from neutron diffraction studies are revealing that residual strain is relaxing not only axially, but also radially. This three-dimensional strain relaxation not only causes the I_c-strain curve to shift in the lower strain direction, but also makes the maximum value of I_c rise. Furthermore, work hardening of the stabilizing material also produced changes in the stress-strain characteristics (see Fig. 2).

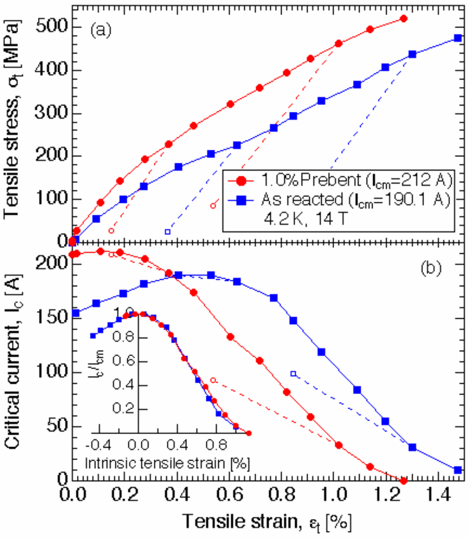

Fig. 2 (a) Stress-strain characteristics of CuNb-reinforced Nb_3Sn wire rod (b) I_c-strain curve of CuNb-reinforced Nb_3Sn wire

Meanwhile, there are also reports of a technology that improves characteristics by applying tensile stress instead of bending strain.[3,4] In that case, the I_c curve shifts in the lower strain direction. However, since this method applies uniform tensile strain to the wire, the stabilizing materials as well as the Nb_3Sn will plastically deform, depending on the structure of the wire, and may even degrade.

3. Applications for Prebending Effect

In this article, we will focus on applying the prebending strain effect to the react-and-wind (R&W) method. The advantage of the R&W method is its low cost because there is no need for a large heat treatment furnace or vacuum impregnation chamber. Combining this with the prebending effect enables the manufacture of coils with good high characteristics at a low cost. Fig. 3 shows the winding method combining the R&W method with prebending treatment. The wire is repeatedly bent using 10 pulleys, and then while it is being coiled, it is impregnated with an epoxy resin applied with a brush. The size of bending strain is controlled by the size of the pulleys.

There is a large improvement in I_c when comparing the energization results at 4.2 K on a coil wound by varying the size of the prebending strain applied with the I_c of the shorter sample, thereby proving the effectiveness of the prebending R&W method.[5]

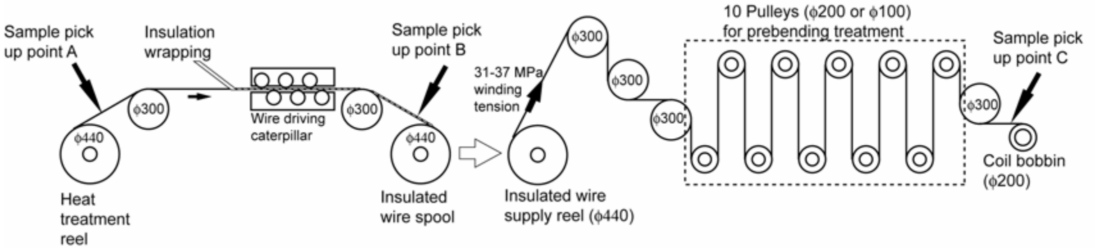

Fig. 3 R&W method combined with prebending effect

4 Conclusion

This article introduced some of the results that have been obtained thus far and the current state of applied research for the prebending effect. We are currently in the process of manufacturing coils on a practical scale (about the size able to produce a magnetic field), and we plan to conduct verification tests shortly. Another application is cabling. We are attempting to twist Nb_3Sn wire that is normally cable-formed before heat treatment by first applying a prebending treatment to strands after heat treatment to improve characteristics before cabling. We have just launched joint research with the National Institute for Materials Science on developing wire and conductors for a 50 T-class hybrid magnet.

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3) Agatsuma *et al*., Unexamined Japanese Patent Application No. 60-101811
4) S. Ochiai, Cryogenics, 32 (1992) 584
5) G. Nishijima *et al*., Supercond. Sci. Technol. 18 (2006) S261

(Published in a Japanese version in the April 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

Superconductivity

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Published by International Superconductivity Technology Center
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Feature Articles: Advances in Superconducting Materials Technology - Technology for Increasing Performance of Bi-2223 Superconductive Wire Rod -

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It appears that the performance of bismuth superconducting wire will continue to improve. Over the past several years, wire rod performance has steadily advanced, and it is now possible to produce continuous wire rod with an I_c (critical current) exceeding 200 A at 77 K and under a self-magnetic field. (The latest data shows wire with a critical current I_c of 211 A, which comes out 500 A/cm.) The improved performance of such bismuth superconducting wire relies heavily on the introduction of a high-pressure sintering process known at the controlled over-pressure (CT-OP) method. This method performs the final sintering of wire rod while precisely controlling temperature and oxygen partial pressure under a high-pressure environment of about 300 atmospheres, resulting in bismuth superconducting wire with a 100 % density and no voids. (We are referring to it as DI-BSCCO wire to distinguish it from conventional BSCCO wire sintered under normal atmospheric pressure.)

With conventional wire rod sintered under normal atmospheric pressure, there will always be voids after the manufacturing process. These voids are the cause of lower electrical and mechanical characteristics. It is also the cause of variability within wires lots as well performance and reproducibility between lots, but by introducing pressurized sintering, we were able to avoid such variability for the first time. This can also be interpreted as the parameter design of each manufacturing process that applies input characteristics being possible under ideal conditions with no noise (voids) for the output characteristic *Ic*. We actually carried out a detailed review and improvement of the manufacturing parameters for all processes, from material to sintering, after the introduction of pressurized sintering, and as a result, we were able to raise the output characteristic *Ic* to 211 A. Cost performance of $100/kAm is now in sight thanks to our ability to make continuous wires exceeding 200 A. This, however, is not our final goal. We believe there is still room for improving DI-BSCCO wire. Actually, there is a non-superconducting phase in the superconducting structure of I_c = 211 A wire rod, and it is hindering the bonding and orientation of superconducting crystals. We believe performance (I_c) can be further improved simply by improving this situation. The industrial production of DI-BSCCO is still in its infancy, so there is still room for improvement in terms of cost by the mass production effect. In fact, we believe that cost performance can be brought down to the $50/kAm level or less in the near future.

This concludes the introduction of the current state of bismuth superconducting wire. The improvement of performance and cost for such wire is still a work in progress.

(Published in a Japanese version in the April 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

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Feature Articles: Advances in Superconducting Materials Technology
- Prospects for Processing Technology for MgB_2 Wire -

Kazumasa Togano
Superconducting Materials Center
National Institute for Materials Science

MgB_2, a new addition to the ranks of metal-based superconducting materials, is the focus of major interest from both the physical and application side. In particular, new application advances that were not possible with Nb-Ti and Nb_3Sn can be expected because its high T_c near 40 K makes it easy to apply a cryocooler and it can even be used within liquid hydrogen. Furthermore it is a simple material comprised of two abundant elements and is a stable compound, both of which are major advantages in terms of manufacturing. Wire development exploiting these strengths is currently flourishing and advances are steadily being made.

Most MgB_2 wire rod is currently being made on a trial basis using the powder-in-tube (PIT) method. This method is broadly classified into the in-situ method in which a powder mixture consisting of Mg and B is packed into a metal tube, processed, and then heat treated, and the ex-situ method in which MgB_2 powder that has already been synthesized is packed into a metal tube and then processed, but either one is highly advantageous in terms of its simplicity and ease of manufacturing long wire. As a result, there have been reports of wires several hundred meters long, and more recently, even those a kilometer long. Furthermore, even coil tests are now being carried out using this type of wire. However, its magnetic field characteristics have not yet reached a practical level, and efforts to elucidate the pinning mechanism and improve characteristics based on that knowledge will no doubt continue.

Table1 MgB_2 wire process

I. Powder-in-tube (PIT) method
    In-suit method
    Ex-situ method
II. Attempts using methods other than PIT
    1) B fiber method
        Reaction Mg vapor phase or Mg liquid phase
    2) Coated conductor method
        Vapor-phase growth (PLD, HPCVD etc.), electric plating, coating method
    3) Modified-PIT method
        PICT method, Infiltration method
        Composite processing method

On the other hand, it is inherently difficult for the PIT method to achieve a high-density structure because it is basically a sintering reaction between two powders. Increasing structural density will be a major issue in improving J_c. To that end, we must develop a wide range of processes, as shown in Table 1, rather than focusing solely on the PIT method. In terms of increasing wire length, it would be ideal if we could generate MgB_2 layers by a diffusion reaction at the composite interface. With MgB_2, however, it is difficult to achieve a composite structure because pure Mg is extremely difficult to work with. In response, my group recently succeeded in manufacturing MgB_2 wire on a trial basis using a composite processing method that uses an Mg-Li alloy, which has exceptional workability. Fig. 1 (a) is composite wire in which we packed B power into the gap between an Fe sheath material and a Mg-Li alloy core. Workability is extremely good and cold working is possible with a large reduction in area and without intermediate annealing. Heat-treating this produces an MgB_2 layer on the inside of the Fe sheath material, as shown in Fig. 1 (b). Li is generated as a precipitate inside the MgB_2 matrix without dissolving into the MgB_2 phase, and thus there are no ill effects to MgB_2 superconductivity. The MgB_2 phase has an extremely dense structure because it is generated by a diffusion reaction. We now plan on improving manufacturing conditions and studying the potential for practical applications.

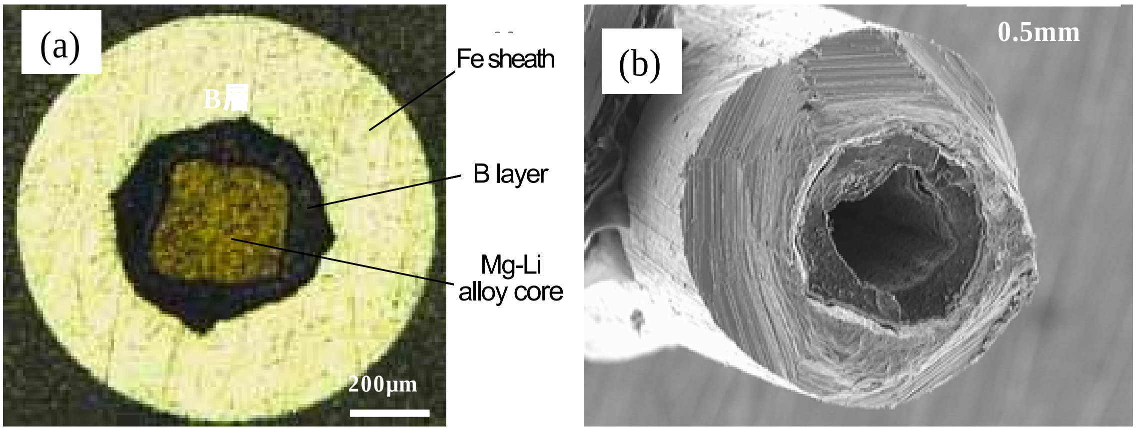

Fig.1(a) Photo of cross section structure of Fe/B/Mg-Li composite wire

(b)Photo of above wire after heat treatment taken with a scanning electron microscope (SEM)

The performance of PIT-MgB_2 wire has markedly improved over the past five years. From this point forward, we will seek further improvements in J_c, work to establish production technology, including the production of multicore wire, stabilization, and the creation of conductors, and conduct practical performance evaluations that include mechanical characteristics and stability. In addition, experimental applications to PCS and current leads will no doubt advance. We also believe that process development seeking new breakthrough beyond the PIT method will also be carried out at the same time, as introduced as an example in this article.

(Published in a Japanese version in the April 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007
超電導 Web21
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Feature Articles: Advances in Superconducting Materials Technology

- Current State of Practical Characteristics of REBCO Bulk Superconductors -

Bulk superconductors are composite materials in which a phase 2, such as RE211, is finely dispersed at a level of about 30 % to 40 % within an RE123 superconducting phase and then the RE123 crystals are grown larger by means of the melt growth method. They are characterized in part by their ability to produce small artificial magnets that have magnetism several times more powerful than permanent magnets by capturing strong magnetic fields, and to enable non-contact levitation through their placement opposite of magnets. The larger the RE123 crystals and the higher the critical current density (J_c), the more the characteristics necessary for applications using such special features improve.

The rare earth elements (RE) that can be used in the RE123 superconducting phase, which is the main component, are as follows when ordered by ion radius size, starting from the largest: La, Nd, Sm, Eu, Gd, Dy, Y, Ho, Er, Tm, and Yb. Critical temperature (T_c) tends to rise as RE ion radius increases. With light rare earth elements (LRE) that have ion radiuses greater than Gd, critical temperatures of 95 K or more have been reported, while at radiuses less than that, critical temperatures of 90 to 93 K maximum have been reported. Since LRE have ion radiuses close to Ba, LRE^{3+} is substituted with Ba sites, resulting in lower T_c. Methods are being developed to suppress this substitution, such as melt growth under low-oxygen partial pressure, but due to the productivity rate among other factors, only materials smaller than Gd, which can be manufactured under a normal atmosphere, are available commercially. Since Gd-based materials experience less substitution, they can achieve a T_c of between 93 and 94 K, even when grown under a normal atmosphere. In addition, since materials smaller than Er have a slow growth rate, they are not used unless special reasons exist.

Critical current density (J_c) depends on the size and quantity of pinning centers. Normally, 77 K self-field J_c is about 30,000 A/cm^2 with Y-based materials and about 50,000 to 60,000 A/cm^2 with Gd-based materials. The use of LRE such as Gd introduces pinning centers with compositional variability due to LRE/Ba substitution, and J_c with a high magnetic field improves as shown by the peak effect on the J_c-B curve. In addition, after preparing and using a finely crushed powder, 77 K self-field J_c was greatly improvable to the 300,000 A/cm^2 level. Furthermore, adding an infinitesimal quantity of Zn or another such material enables the manifestation of the peak effect. The irreversibility field also has compositional and structural dependence, and at 77 K it is 3 to 4 T with Y-based materials and about 5 T with Gd-based materials. With compositions that have a special combination of Nd, Eu, and Gd, there are reports even of materials with an irreversibility field raised to 14 T at 77 K. And when cooled to 40 K, J_c rises by about one figure.

The trapped magnetic field characteristic at 77 K is about 0.5 to 1.0 T with Y-based materials. Since Gd-based materials have a higher J_c in a high magnetic field than Y-based materials, they achieve a high trapped magnetic field of around 2 T. In addition, with Gd123 bulk superconductors, which are dispersed into the minute 211 phase and have an approximate 65-mm diameter, a high trapped magnetic field of 3 T and 9 T can be achieved at 77 K and 40 K, respectively. Furthermore, with Y123-based materials with a diameter of 24 mm, high trapped magnetic fields exceeding 17 T at 29 K have been confirmed. The aforementioned values were obtained using the field magnetism (FM) method in which the sample is cryocooled while applying a static magnetic field and then a bulk superconductor is magnetized after eliminating external magnetic fields. As for the pulse field magnetism method in which a pulse field is applied, it achieved characteristics on par with the FM method at 77 K, but at present, the maximum trapped magnetic field is 5.2 T at 20 K, which means there is still room for improvement.

The application performance of bulk semiconductors increases as crystal size gets larger. General materials have diameters between 32 and 60 mm, but in recent years, large bulks exceeding 140 mm have be obtained. The increasing size or thickness of bulks not only improves trapped magnetic fields, but also results in characteristics such as increased repulsion with magnets, field strength at long distances, and an increasing field gradient.

Bulk superconductors have strong compressive stress (compressive strength of several 100 MPa or more), but tension strength in a-axis direction is a weak 10 to 70 MPa and lacks uniformity. That is why a large Lorentz force in the tension direction arises in superconductors and causes them to break down when a high magnetic field is trapped in a bulk superconductor to magnetize it. Therefore, improving strength is essential to trapping high magnetic fields of 5 T or more. Methods for improving strength include adding about 10 % to 20 %-Ag, using reinforced rings, and reinforcement through resin impregnation, and by combining these methods, we can raise strength and decrease variability.

There is also the problem of performance degrading due to the heat generated by bulks when an AC field is applied. One of the reasons for this is that bulk semiconductors have poor thermal conduction. Countermeasures include using rings made of Al, which have high thermal conduction, and forming holes parallel to the c axis on bulk semiconductors, inserting aluminum wires into the holes, and then using a sample vacuum-impregnated with a low-melt temperature metal. Such countermeasures have made it possible to suppress the temperature increase of samples and prevent the reduction of trapped fields.

The performance of bulk superconductors is markedly improving as this article has shown. We expect new applications to develop once it becomes possible to provide inexpensive and stable materials.

(Naomichi Sakai, Bulk Superconductor Laboratory, Division of Material Science & Physics, SRL/ISTEC)

(Published in a Japanese version in the April 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

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Published by International Superconductivity Technology Center
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Superconductivity-Related Product Guide

- Superconducting Wire/Bulk-Related Products
(Company names in Japanese syllabary order)

Nb-Ti Alloy Composite Superconducting Wire

- Japan Superconductor Technology Inc. (JASTEC), Wire Department
Wire for NMR/MRI spectrometers, wires for magnets
Contact: Mr. Yukinobu Murakami
Tel: 093-391-2836, Fax: 093-391-2847
- Hitachi Cable, Ltd., Electrical Copper Department, Electrical Copper Division, High Performance Materials & Component Products Group
Conductors for nuclear fusion reactors and accelerators, conductors for pulsed magnetic fields
Contact: Mr. Katsumi Miyashita
Tel: 029-826-7416, Fax: 029-826-1846
- The Furukawa Electric Co., Ltd., Superconducting Product Sales Section, Second Sales Department, Metal Company
Conductors for high-energy accelerators, conductors for varying magnetic fields, and various copper-stabilized Nb-Ti conductors
Contact: Mr. Shimizu
Tel: 03-3286-3161, Fax: 03-3286-3663
- Mitsubishi Electric Corporation, Superconducting Technology Group, Magnetic Applications Advanced System Department, Power and Industrial System Office
PVF-insulated superconductive wires
Contact: Mr. Naohiro Miyata, Nuclear Power Sales Section 2, Nuclear Power Department
Tel: 03-3218-2607

Nb_3Sn Composite Superconducting Wires
- Japan Superconductor Technology Inc. (JASTEC), Wire Department
Wire for NMR spectrometers, wire for high-field magnets, high-strength wires, stranding wires for nuclear fusion reactors
Contact: Mr. Yukinobu Murakami
Tel: 093-391-2836, Fax: 093-391-2847
- Hitachi Cable, Ltd., Electrical Copper Department, Electrical Copper Division, High Performance Materials & Component Products Group
Conductors for high-field magnets, conductors for nuclear fusion reactors
Contact: Mr. Katsumi Miyashita
Tel: 029-826-7416, Fax: 029-826-1846
- The Furukawa Electric Co., Ltd., Superconducting Product Sales Section, Second Sales Department, Metal Company
Wires for NMR analyzers, conductors for high-field magnets, CICC strands for nuclear fusion reactors
Contact: Mr. Shimizu
Tel: 03-3286-3161, Fax: 03-3286-3663
- Mitsubishi Electric Corporation, Superconducting Technology Group, Magnetic Applications Advanced System Department, Power and Industrial System Office

Low hysteresis loss strands for nuclear fusion reactors, direct current high critical current density strands
Contact: Mr. Naohiro Miyata, Nuclear Power Sales Section 2, Nuclear Power Department
Tel: 03-3218-2607

Nb_3Al Composite Superconducting Wires
- Hitachi Cable, Ltd., Electrical Copper Department, Electrical Copper Division, High Performance Materials & Component Products Group
Conductors for high magnetic field magnets, conductors for nuclear fusion
Contact: Mr. Katsumi Miyashita
Tel: 029-826-7416, Fax: 029-826-1846

Silver-Sheathed Bismuth Oxide Superconducting Wires
- Showa Cable System Co., Ltd., Superconductivity Project, Technical Development Center
Silver-sheathed Bi-2212 wires, current leads
Contact: Mr. Yuji Aoki
Tel: 042-773-7163, Fax: 042-773-7291
- Sumitomo Electric Industries Ltd., HTS R&D Department
Silver-sheathed Bi-2223 tape
Contact: Mr. Yuichi Yamada
Tel: 06-6466-5537, Fax: 06-6466-5705
- Hitachi Cable, Ltd., Electrical Copper Department, Electrical Copper Division, High Performance Materials & Component Products Group
Contact: Mr. Katsumi Miyashita
Tel: 029-826-7416, Fax: 029-826-1846

Bulks
- Nippon Steel Corporation
Superconducting bulk materials, various sample products including bulk superconducting current leads, coil magnets using superconducting bulks (under development)
Contact: Mr. Hidekazu Teshima
Tel: 0439-80-2713, Fax: 0439-80-2746 e-mail: teshima.hidekazu@nsc.co.jp

(Yasuzo Tanaka, Editor)

(Published in a Japanese version in the April 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Superconductivity

Summer, 2007 Date of Issue: July 17, 2007

Superconductivity Web21

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Patent Information

Introduction of Published Unexamined Patents in the 4th Quarter of Fiscal 2006

The following are ISTEC's patents published from January through March 2007. For more information, access the homepage of the Patent Office of Japan and visit the Industrial Property Digital Library (IPDL).

1) Publication No. 2007-12582: "RE-based Oxide Superconductive Wire Joining Method"

This invention relates to a joining method for RE-based oxide superconductive wire. Reduction of connecting resistance at the junction between two oxide superconductive wires or between an oxide superconductive wire and a metal wire is an important issue in equipment applications of oxide superconductive wires. The invention joins together two RE-based oxide superconductive wires covered with a metal material or a said wire and a metal wire, by applying thermal energy and oxygen pressure to the junction where two metal surfaces of the both wires are stacked. Since this joining method is not only extremely simple, but also can employ temperatures lower than the temperature at which oxygen escapes from oxide superconductive wire, there are no losses in the superior transport characteristics of superconductive wire and no more processing, such as annealing, after joining wires, and low-resistance junctions can be formed with good reproducibility.

2) Publication No. 2007-27636: "Superconductive Storage Cell"

This invention relates to a circuit configuration of a superconducting random access memory. In the past, proposals have been made for simple circuit configuration cells that operate using a unipolar selection signal but have a low operating margin, and for high operating margin cells that operate using a bipolar selection signal but have a complex circuit configuration. This invention provides a memory circuit configuration that has a high operating margin for the half-selection state that either of a row and a column is selected in the read cycle and is able to operate with a unipolar selection signal. This configuration is characterized as follows. It is comprised of superconducting loop no.1, which includes a write gate and Josephson junction no.1; superconducting loop no.2, which includes Josephson junction no.1; read gate magnetically coupled with superconducting loop no.2; and a control line magnetically coupled with superconducting loop no.1. The product of the total inductance value of superconducting loop no.1 and the superconducting critical current value of the write gate is set so that it will be single flux quantum Φ_0 or more, and the product of the total inductance value of superconducting loop no.2 and the superconducting critical current value of Josephson junction no.1 is set so that it will be single flux quantum Φ_0 or less.

3) Publication No. 2007-70177: "Manufacturing Method for Oxide Superconductive Material and Substrate for Supporting Precursor"

This invention relates to the manufacturing method for RE123-based oxide bulk superconductor which is made from a precursor with the partial-melt solidification technique. This manufacturing method requires a supporting substrate to hold the precursor during heat treatment. The material for the supporting substrate was selected in light of the fact that the superconductive characteristics are usually degraded due to impurities that are penetrated into the superconductor from the substrate during heat treatment, and cracks occur due to the difference in thermal expansion coefficient between the partial-melted precursor and the supporting substrate. In the case of the long duration of heat treatment for large bulks, there have been proposals such as an insertion sheet between the supporting substrate and the precursor, but it is not applied to bulks larger than 7 cm. This invention is featured in a supporting substrate surface being a mixture of RE' compound powder, Ba compound powder, Cu compound powder and granular particles of RE''_2BaCuO_5 (RE' and RE" are individually a rare earth element other than RE). And RE' and RE" are selected so that the crystal growth temperature of the (RE', RE")-Ba-Cu-O superconductor phase will be lower than the crystal growth temperature of the RE-Ba-Cu-O superconductor phase in the precursor. This has enabled the stable manufacture of large bulk superconductor and without any cracks.

4) Publication No. 2007-71659: "Continuous Magnetic Flux Observation System and Method"
This invention relates to a continuous magnetic flux observation system for estimating discontinuity in the superconducting characteristics of superconductive long wire. It is characterized by the use of in-plane magnetized magneto-optical film (MO film) as the means for observing magnetic flux, a wire transfer structure comprised of a wire reel out section and wire reel up section for intermittently feeding the superconductive wire, a wire holding section for holding the superconductive wire, an electromagnet that generates appropriate magnetic field perpendicular to the tape surface of the superconductive wire, an MO film holder that attaches/detaches the MO film to/from the surface of the superconductive wire, illumination optics for emitting linearly-polarized light onto the MO film, an imaging section for observing the polarization distribution by the MO film, and a cryocooler for controlling the temperature of the wire holding section in order to set the superconductive wire to a given temperature on the observation position. This invention has made it possible to continuously and efficiently measure the longitudinal distribution of magnetic flux density with high-resolution under a given temperature for testing sample.

5) Publication No. 2007-74120: "Superconducting Circuit"
The superconducting circuit is characterized by low power consumption and fast operation exceeding 10 GHz. Such fast operation requires a high accurate high-frequency clock generation with little jitter which cannot be implemented by an external clock generated at room temperature. In the past, frequency multiplier circuits, Josephson junction transmission lines (JTL) shaping circuits, and the like were also used for the sine wave signal input from an external source, but equidistant pulses with adequately high accuracy could not be achieved. In this invention, Josephson junction no.1 and Josephson junction no.2, which have different thresholds, are arranged in a superconducting loop, and one junction presets single flux quantum pulse and then the other junction resets the pulse. By having different thresholds for the no.1 and no.2 Josephson junctions, each Josephson junction ends up being switched only once per cycle of sine wave input, and two same superconducting loops were employed in this invention. The superconducting loop No.1 is connected to a secondary inductor of a transformer for an input sine wave signal and the superconducting loop No.2 is connected to the other secondary inductor to get the opposite phase sine wave signal. The frequency multiplication is realized by superimposing the single flux quantum pulses from superconducting loop no.1 and the superconducting loop no.2. This invention has made it possible to generate a clock signal exceeding 20 GHz.

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

(Published in a Japanese version in the May 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Summer, 2007 Date of Issue: July 17, 2007

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Published by International Superconductivity Technology Center
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Standardization Activities

Topics in April

- JIS H 7312: 2007 “Residual resistance ratio of Nb_3Sn composite superconductors” issued -

The Japan Standards Association (JSA) and the International Superconductivity Technology Center (ISTEC) issued JIS H 7312: 2007 “Superconductivity — Residual resistance ratio measurement — Residual resistance ratio of Nb_3Sn composite superconductors” on February 20, 2007 after deliberation by the Japanese Industrial Standards Committee.

Since this JIS standard is an alignment with IEC 61788-11: 2003*, it was drafted by the JIS Standardization Planning Committee (chaired by Prof. Kozo Osamura), which was established under the IEC/TC90 Superconductivity Committee.
* IEC 61788-11: 2003, Superconductivity — Part 11: Superconductivity — Residual resistance ratio measurement — Residual resistance ratio of Nb_3Sn composite superconductors

Organization of standard: Standards body; introduction, scope, normative reference, definitions, requirements, apparatus, sample preparation, test method, precision and accuracy of test method, reporting matters, Annex A and explanations.

- Scope -

This standard covers a test method for the determination of the residual resistance ratio (*RRR*) of Nb_3Sn composite conductors. This method is intended for use with superconductor specimens that have a monolithic structure with a rectangular or round cross section, *RRR* less than 350 and cross-sectional area less than 3 mm^2, and have received a reaction heat-treatment. Ideally, it is intended that the specimens are as straight as possible; however, this is not always the case, thus care must be taken to measure the specimen in its as received condition. All measurements are done without an applied magnetic field.

The method described in the body of this standard is the “reference” method; optional acquisition methods are outlined in Annex A.

- Definition of residual resistance ratio (*RRR*) -

The ratio of resistance at room temperature to resistance immediately upon superconducting transition

In other words, *RRR* is as follows:

$RRR = R_1/R_2$ R_1: Resistance at room temperature (293 K)
R_2: Resistance just above upon superconducting transition

(Yasuzo Tanaka, Director, Standardization Department, ISTEC)

(Published in a Japanese version in the April 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21

Standardization Activities

Topics in May
- IEC Revises/Issues Five Superconductivity-Related Standards -

The International Electrotechnical Commission (IEC) is performing sequential maintenance on its current 14 superconductivity-related standards, and in 2006, it revised/issued the following five standards.

- IEC 61788-1-Ed. 2.0: 2006-11 Superconductivity-Part 1: Critical current measurement-DC critical current of Cu/Nb-Ti composite superconductors**

- IEC 61788-2-Ed. 2.0: 2006-11 Superconductivity-Part 2: Critical current measurement-DC critical current of Nb_3Sn composite superconductors**

- IEC 61788-3-Ed. 2.0: 2006-4 Superconductivity-Part 3: Critical current measurement-DC critical current of Ag- sheathed Bi-2212 and Bi-2223 oxide superconductors*

- IEC 61788-7-Ed. 2.0: 2006-10 Superconductivity-Part 7: Electronic characteristic measurements -Surface resistance of superconductors at microwave frequencies**

- IEC 61788-10-Ed. 2.0: 2006-8 Superconductivity-Part 10: Critical temperature measurement -Critical temperature of Nb-Ti, Nb_3Sn, and Bi-system oxide composite superconductors by a resistance method*

* Maintenance result date : 2009
** Maintenance result date : 2010

Substantial maintenance on these standards commenced with the 9th International Electrotechnical Commission/Technical Committee 90 (Superconductivity) (IEC/TC90) held in 2004 at the Argonne National Laboratory in the U.S., and their approval was deliberated at the 10th IEC/TC90 held in 2006 in Kyoto, Japan.

The main revisions are as follows:

- IEC 61788-1-Ed.2.0: Title changed and other revisions made, including expanding the scope to general Nb-Ti composite superconducting wires that include three-component wires.
- IEC 61788-2-Ed.2.0: Revisions include adding the one-mandrel method to the two-mandrel method.
- IEC 61788-3-Ed.2.0: Revisions include the revision of technical details and editorial corrections.
- IEC 61788-7-Ed.2.0: Revisions include changes to the structure of technical descriptions, the expansion of the mode chart, and the expansion of the sapphire cylinder dimensional notations.
- IEC 61788-10-Ed.2.0: Revisions include a change in title and the expansion in scope to include general superconducting wires.

(Yasuzo Tanaka, Director, Standardization Department, ISTEC)

(Published in a Japanese version in the May 2007 issue of *Superconductivity Web 21*)

Top of Superconductivity Web21