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超電導 Web21 Superconductivity

Superconductivity Web21

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Exhibition of "Superconductivity Pavilion" at Eco-Products 2009

Minako Oka, Assistant Manager
Public Relations Division, ISTEC

"Eco-Products 2009," hosted by Nikkei Inc., was held for three days from December 10 to 12 at Tokyo Big Sight in Ariake, Koto-ku, Tokyo. This year's exhibition was presented as "Superconductivity Pavilion" in place of "SUPERCONDUCTIVITY EXPO" that had been held two years ago, and various activities were performed for information exchange, promotion, and enlightenment on superconducting technologies.

At the "Superconductivity Pavilion," exhibitions were presented by five companies and groups who have been promoting the research and development of superconductivity.
SWCC Showa Holdings Co., Ltd., exhibited Y-based superconducting wires and current leads.
Sumitomo Electric Industries, Ltd., exhibited a superconducting motor installed on an electric vehicle, a sectional model of an actual three-phase superconducting cable, bismuth-based wires, etc.
Fujikura Ltd. exhibited a 500-m Y-based superconducting wire, magnets that use the Y-based superconducting wire, etc.
Furukawa Electric Co., Ltd., exhibited metal-based superconducting wires, sectional models of Y-based superconducting cables, and thin-film current-limiting elements, etc. (The company names above are in alphabetical order)

In addition, ISTEC exhibited a diorama entitled "Affluent Future Society developed by Superconductivity;" models of superconducting wires used for SMES and transforms, etc., where the wires were divided into five 5-mm widths; and superconducting elements.

Superconductivity Pavilion (movie)

Until last year, each company presented its individual exhibition, but this year's "Superconductivity Pavilion" was presented jointly and in tandem as a single "Superconductivity Booth." Therefore, visitors were able to compare between companies, and exhibitors were able to provide detailed descriptions that went beyond individual corporate frameworks.
In addition, since the space secured was larger than that for an exhibition presented by a single company, it was easier to see displayed items, and the demonstration space secured was also sufficiently large. This allowed large-scale demonstrations to be performed, thereby attracting many visitors to the booth during the exhibition.

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The “Demonstration Stage” held at hourly intervals was a great success; each time, it was crowed with many people and some were squeezed out onto the pathways. With a touch of humor, basic ideas, including "history of superconductivity," “what is superconductivity?,” and “application of superconductivity,” were clearly explained; and by actually using a demonstration kit, it was demonstrated to the visitors that a superconducting magnet is powerful enough to lift a person.

The number of visitors clearly shows the increased interest in ecology (eco) and the environment. This year, the total number of visitors was 182,510, and the number of visitors has been increasing every year (2007: 164,903, 2008: 173,917).
It was our third presentation from the “SUPERCONDUCTIVITY EXPO” to this year’s “Superconductivity Pavilion” at the Eco-Products Exhibition. This time, we conducted a “questionnaire of visitors” targeted at 1,000 people, and the number of visitors to the “Superconductivity Pavilion” booth seemed to be doubled or tripled, estimating on the basis of the number of distributed questionnaires. Inside the booth, the explainers were too busy to attend to all the visitors. It was notable that there were many businesspersons among the visitors. In addition, there were visitors of various age groups, such as elementary and junior-high-school students in small groups visiting for extracurricular activity, and families comprising babies.

The increased interest in superconducting technologies was discernible by the fact that many visitors were asking very specific questions about “superconductivity technologies” and “application of superconductivity technologies,” and they were listing intently to the answers.

While we renewed our awareness of the meaning and necessity of continuing to present at such an exhibition, we felt that we achieved our purposes such as information exchange, promotion, and enlightenment on superconducting technologies at this exhibition.

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What's New in the World of Superconductivity (February, 2010)

Akihiko Tsutai, Director
International Affairs Division, ISTEC

Award

Zenergy Power plc (February 11, 2010)

Zenergy Power plc and its partner Bültmann GmbH have been awarded the coveted "Innovation Prize for Climate Protection" from the German Federal Ministry for the Environment and the Federation of German Industry. The award was given in recognition of the environmental benefits of the world's first industrial-scale superconducting magnetic billet heater. The heater is used for commercial applications in metals manufacturing and is capable of saving huge amounts of electrical power, thereby reducing both carbon dioxide emissions and operating costs. The first installation of this heater, in an aluminum processing plant, has already reduced power consumption by half while increasing productivity by 25%. Germany's Federal Foundation for the Environment has estimated that the new superconducting magnetic billet heater could reduce carbon dioxide emissions by an amount equivalent to two coal power plants in Germany alone. At present, five units have been sold to customers throughout Europe.
Source:
"Environmental Award"
Zenergy Power plc press release (February 11, 2010)
http://www.zenergypower.com/images/Presse/IKU-Environmental-Award-2010.pdf

Organization

University of Houston (February 3, 2010)

The University of Houston has received a Research Superiority Award from the Texas Emerging Technology Fund (ETF) to help establish the Texas Center for Superconductivity (TcSUH)"s Applied Research Hub (TcSUH-ARH) and to recruit researchers in superconductivity and related fields. The award is worth $3.5 million over a 5-year period. The TcSUH-ARH will help to transfer HTS and other advanced material research and technology developed by TcSUH to commercial applications by promoting research collaborations and licensing agreements with industry or forming spin-off companies, as appropriate. Initially, work will focus on the improvement and commercialization of superconducting wire for applications in the field of energy; these efforts will be undertaken in partnership with SuperPower Inc. The TcSUH-ARH will also work with industry to develop HTS applications in the field of biomedicine (medical imaging and nanomedicine).
Source:
"UH Superconductivity Center Receives Texas Emerging Technology Fund Award"

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University of Houston press release (February 3, 2010)
http://www.uh.edu/news-events/stories/2010articles/Feb2010/0203ETF.php

Exhibition

Superconductor Technologies Inc. (February 18, 2010)

Superconductor Technologies Inc. (STI) will exhibit recent advances in the production of second-generation HTS wires at the Advanced Research Projects Agency – Energy (ARPA-E) Energy Innovation Summit, to be held March 1 – 3, 2010, in Washington, DC. The event will showcase ARPA-E award winners and finalists, displaying next-generation clean energy technologies. Jeff Quiram, president and CEO of STI, commented, "We are excited to be recognized with other companies and research organizations poised to transform our energy economy. Our joint proposal with GE Global Research and Los Alamos National Laboratory for the development of a commercially viable production process for 2G HTS wire was one of 300 finalists out of approximately 3,700 initial submissions." STI is working on the development of a more efficient, scalable manufacturing process for HTS wire. At present, they are producing initial lengths and working to enhance the performance of HTS wire for various commercial applications.
Source:
“STI to Exhibit Advancements in 2G HTS Wire Production at the ARPA-E Energy Innovation Summit March 1-3”
Superconductor Technologies Inc. press release (February 18, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1392355&highlight

Power

American Superconductor Corporation (February 1, 2010)

American Superconductor Corporation (AMSC) has received an initial order worth approximately US $70 million for full wind turbine electrical control systems from Shenyang Blower Works (Group) Co., Ltd. (SBW, China). The electrical control systems will be installed in the 2-MW doubly fed induction wind turbines that SBW is codeveloping with AMSC’s wholly owned subsidiary AMSC Windtec™. Greg Yurek, founder and chief executive officer of AMSC, commented, "The magnitude of this electrical control system contract sends a strong signal that Shenyang Blower Works is positioned to be a key player in China's vibrant wind power market. The company is planning to begin volume production later this year and sees significant long-term potential for this new line of business. AMSC expects to help every step of the way with its world-class wind turbine engineering, customer service and electrical control technologies and products." The present order is the largest initial order for electrical control systems that AMSC has ever received. AMSC expects to begin shipping the electrical control systems in the second half of calendar 2010 and to complete the shipments by the first half of calendar 2013.
Source:
“AMSC Receives $70 Million Order for Wind Turbine Electrical Control Systems from China’s Shenyang Blower Works”
American Superconductor Corporation press release (February 1, 2010)

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http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1381108&highlight

American Superconductor Corporation (February 2, 2010)

American Superconductor Corporation (AMSC) has reported record financial results for its third quarter of fiscal 2009, ending December 31, 2009. Revenues for the quarter increased by 95 % to US $80.7 million, compared with $41.3 million for the same quarter in the previous fiscal year. The gross margin for the third quarter was 37.5 %, compared with 23.2 % for the third quarter in the previous fiscal year. The GAAP net income for the quarter was $5.2 million (compared with a net loss of $7.8 million for the previous third quarter), and the non-GAAP income was $9.1 million (compared with a net loss of $4.9 million for the previous third quarter). As of December 31, 2009, the company had $112.8 million in cash, cash equivalents, marketable securities and restricted cash. However, as of January 31, 2010, AMSC's balance had increased to more than $135 million. The backlog as of the end of the third quarter was approximately $546 million. Greg Yurek, AMSC's founder and chief executive officer, commented, "We delivered better-than-expected financial results for the third fiscal quarter as wind-related revenues continued to grow and our cost management initiatives provided additional bottom-line benefits. With several wind turbine manufacturing customers in volume production, many others set to begin production over the next 12 months and new power grid orders continuing to be closed, the foundation has been set for further growth in fiscal 2010 and beyond."

As a result of their record third-quarter financial results, AMSC is increasing its full-year guidance for revenue (from $300 million – $310 million to $312 million – $315 million) and net income (GAAP: from $11.0 million – $13.0 million to $14.0 million – $15.0 million; non-GAAP: $27.0 million – $29.0 million to $29.5 million – $30.5 million). AMSC is expected to continue growing in fiscal 2010, with anticipated revenue of more than $400 million and anticipated non-GAAP income of more than $54 million.

Source:
"AMSC Reports Third Quarter Fiscal Year 2009 Financial Results"
American Superconductor Corporation press release (February 2, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1381655&highlight

American Superconductor Corporation (February 25, 2010)

American Superconductor Corporation (AMSC) has been named one of the 50 most innovative companies in the world by Massachusetts Institute of Technology's *Technology Review* (TR50). This is the first time that *Technology Review* has compiled such a list. To be eligible for selection, companies must be responsible for important inventions and breakthroughs and be successfully growing businesses and markets around innovative products. Regarding the selection of AMSC, David Rotman, editor of *Technology Review*, commented, "American Superconductor's innovative electricity cables could help modernize the power grid and make remote sources of renewable wind and solar power far more accessible. Its superconductor cables could truly play a key role in updating our electricity infrastructure." Other companies listed on the TR50 include Apple, DuPont, First Solar, GE, IBM, and Nissan.

Source:
"AMSC Named one of the World's 50 Most Innovative Companies"
American Superconductor Corporation press release (February 25, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=86422&p=irol-newsArticle_Print&ID=1395387&highlight

University of Wisconsin-Madison (February 28, 2010)

Researchers at the University of Wisconsin-Madison, in collaboration with the National High Magnetic Field Laboratory and the University of Michigan, have developed a breakthrough approach to

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fabricate thin films of pnictides with a current-carrying potential 500 times that of previous experiments. The group engineered a thin template made from barium titanate or strontium titanate that has both metallic and oxide elements; this template was then used as an interface between the oxide substrate and the superconducting thin film. The template enables the superconducting thin film to grow in a more ideal arrangement and also acts as a nucleation layer, or barrier, between the conducting thin film and the insulating substrate. The resulting single-crystal thin films of pnictides are expected to advance research on the fundamental mechanisms at work in pnictides. Additionally, this template growth method should also be applicable for other situations where a metallic film must be grown on an oxide substrate. The group's approach and results were published online in *Nature Materials*.
Source:
"Template engineering demonstrates possibilities of new superconducting material"
University of Wisconsin-Madison press release (February 28, 2010)
http://www.news.wisc.edu/17741

MRI

Luvata (February 11, 2010)

Luvata has won a $6.5 million contract from the Commissariat à l'énergie atomique (CEA) Saclay to supply niobium titanium superconducting wire for a whole-body MRI system (the "Iseult project"). The contract includes an option for additional materials to possibly be purchased at a later date for a combined value of over $10 million. Luvata will be the sole supplier of superconducting wire for the project, which will require two types of superconducting wire: 158 km of cable-in-channel superconductor for the main coils, and 60 km of wire-in-channel superconductor for the shield coils. The field strength of the MRI will be 11.75 Tesla. Franck Lethimonnier, the manager of the Iseult project, commented, "This incredibly powerful 11.75-Tesla whole-body MRI system will allow us to see body tissue structures with a clarity that has never been possible before due to technological limitations and reveal details that are currently invisible at lower magnetic fields. Ultimately, after a large R&D effort by CEA and industrial partners, this MRI should provide earlier detection of and treatment for diseases currently undetectable with today's clinical MRI units and we hope will be a platform for a range of medical and treatment advances in the years to come."
Source:
"Luvata wins $6.5 million contract from CEA Saclay"
Luvata press release (February 11, 2010)
http://www.luvata.com/en/News-Room/Press-Releases/Luvata-wins-6-5-million-contract-from-CEA-Saclay/

Communication

Superconductor Technologies Inc. (February 25, 2010)

Superconductor Technologies Inc. (STI) has reported its financial results for the fourth quarter of fiscal 2009, ending December 31, 2009. Total net revenues for the third quarter were US $2.2 million, compared with $1.3 million for the same period in the previous fiscal year. Net commercial product revenues were $1.3 million, compared with $686,000 for the same period in the previous fiscal year. Government and other contract revenues totaled $896,000, compared with $592,000 for the same period in the previous fiscal year.

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Net loss for the fourth quarter was $3.5 million, compared with $3.8 million for the same quarter in the previous fiscal year.

For the full-year, the total net revenues were $10.8 million, compared with $11.3 million for fiscal 2008. Net commercial product revenues were $7.2 million, compared with $6.8 million for the previous fiscal year. Government and other contract revenues for 2009 totaled $3.6 million, compared with $4.5 million for 2008. The net loss was $13.0 million, compared with $12.7 million for the previous fiscal year. As of December 31, 2009, STI had $10.4 million in cash and cash equivalents and a commercial product backlog of $795,000.

While fourth quarter revenues were lower than those for the third quarter, mainly because of modest carrier spending, STI did receive new orders for 2010 performance enhancement projects, allowing the company to end the year with a strong backlog.

Source:
"Superconductor Technologies Inc. Reports 2009 Fourth Quarter and Year-end Results"
Superconductor Technologies Inc. press release (February 25, 2010)
http://phx.corporate-ir.net/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1395357&highlight

Basic

Oak Ridge National Laboratory (February 2, 2010)

Using neutron scattering experiments, researchers at Oak Ridge National Laboratory's Spallation Neutron Source (SNS) and the High Flux Isotope Reactor (HFIR) working in collaboration with the ISIS Facility of the Rutherford Appleton Laboratory (U.K.) have obtained evidence indicating that the same mechanisms are involved in both copper-based high-temperature superconductors and iron-based superconductors, assuming that superconductivity is indeed related to a material's magnetic properties. The pairing of electrons in iron-based superconductors is thought to involve magnetic interactions, which act like "glue" to bind the electrons together. To observe the spin excitations, which are thought to be a key factor in the above-mentioned interactions, the researchers subjected single crystals of a material composed of iron, tellurium, and selenium to time-of-flight neutron scattering measurements. Mark Lumsden, the lead researcher at ORNL, commented, " Even in comparison to cuprates, this is experimentally the best indication of what the spin excitations are doing." The group's work was published in *Nature Physics*.

Source:
"New neutron studies support magnetism's role in superconductors"
Oak Ridge National Laboratory press release (February 2, 2010)
http://www.ornl.gov/info/press_releases/get_press_release.cfm?ReleaseNumber=mr20100202-00

Brown University (February 23, 2010)

Researchers at Brown University and at the National Magnetic Field Laboratory in Grenoble (France) have documented, for the first time, a quantum-level phenomenon that occurs in electrons subjected to magnetism in a superconducting material. The researchers observed that under certain conditions, the electrons in a superconducting material (CeCoIn5) formed odd, fluctuating magnetic waves; the fluctuation disappeared when the applied magnetic force was increased. In other words, electron magnets formed repeated wave-like patterns in a manner that was promoted by superconductivity. Furthermore, these waves fluctuated under certain conditions. The discovery is expected to help researchers elucidate the relationship between magnetism and superconductivity at the quantum level and to advance research on superconducting magnets. The group's research was published in *Physical Review*

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Letters.
Source:
“Brown physicist discovers odd, fluctuating magnetic waves”
Brown University press release (February 23, 2010)
http://news.brown.edu/pressreleases/2010/02/mitrovic

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Feature Article: ISS2009 Topics
- The 22nd International Symposium on Superconductivity (ISS2009) -

Masaharu Saeki, Director
Public Relations Division, ISTEC

The International Superconductivity Technology Center (ISTEC) held the International Symposium on Superconductivity (ISS2009) for three days from November 2 (Mon.) to 4 (Wed.), 2009, at the Tsukuba International Congress Center (Epochal Tsukuba). The International Symposium on Superconductivity (ISS), which was the 22nd this year, has been held every year with the aim of facilitating the development and practical application of industrial superconducting technologies and promotion and enlightenment for the general public through announcing the results of research and technological development related to superconductivity at home and abroad and international exchange. This time, the symposium had turned out to be a successful meeting, with a total of 611 participants, including 150 from overseas, and 21 participating countries. There were 133 oral presentations (including 72 by invited speakers) and 315 poster presentations, totaling to 448. The dissertations of the lectures are scheduled to be published as a special edition of the collected papers “Phisica C (Elsevier)”. At the same time, an exhibition for products and technologies of superconductivity-related materials was presented by seven companies and groups.


Opening Ceremony

On the first day, the opening speech was given by Shoji Tanaka, Director Emeritus, Superconductivity Research Laboratory, ISTEC, and a guest felicitation from Mr. Masayuki Naoshima, Minister of Economy, Trade and Industry, was read by Mr. Ichiro Takahara, Director, Kanto Bureau of Economy, Trade and Industry, followed by two special plenary lectures and six plenary lectures hosted by two program chairpersons, Prof. Teruo Matsushita (Kyusyu Institute of Technology) and Prof. Hans Rogalla (University of Twente). At the special plenary lectures, Prof. Hideo Hosono (Tokyo Institute of Technology) delivered a lecture entitled "Iron-based Superconductors: Current Status,” and Dr. Ken Marken (Los Alamos National Laboratory) delivered a lecture entitled “Status of Applications for High Temperature Superconductors in the U.S.” At the plenary lectures, Prof. Yoshihiro Iwasa (Tohoku University) delivered a lecture entitled “Electric Field Induced Superconductivity”; Prof. Pavel Diko (Slovakia Science Academy), "Micro-structural Design of YBCO Bulk Superconductors”; Dr. Teruo Izumi (Superconductivity Research Laboratory, ISTEC), “Research and Development Coated Conductors for Power Applications in Japan”; Dr. Michell Espy (Los Alamos National Laboratory), “Applications of Ultra-low Field Magnetic Resonance”; Dr. Pascal Tixador (National Center for Scientific Research, France), “Development of Superconducting Power Devices in Europe”; and Dr. Noboru Fujiwara (Superconductivity Research Laboratory, ISTEC), “Development of YBCO Power Devices in Japan.” In addition, a banquet was held in the evening to provide a place for active exchanges among the participants.

On the second and third days, oral presentations and two poster sessions were held by dividing them into five fields: Physics and Chemistry/Vortex Physics, Bulks and Characterization, Wires/Tapes and Characterization, Films/Junctions and Electronic Devices, Large Scale System Applications. Active reports and discussions were conducted.

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Further, on the second day, a special session was held to commemorate the late Dr. Masaki Suenaga (Brookhaven National Laboratory), who had contributed to Japan–US collaborative researches, etc. In the physics/chemistry field, the latest topics such as new superconducting materials and clarification of the mechanism for superconductivity were discussed. In the bulk field, the latest topics and research results were reported and discussed, such as researches on fabrication methods aimed at upsizing and improvement of critical current and evaluation technologies toward practical applications. In the wires/tapes field, research reports were presented and active discussions took place; these discussions included the achievements in cutting-edge technology development related to Y-based high-temperature superconducting wires and tapes in Japan, US, and Europe and property evaluation methods for current density and alternating-current loss of tape wires, as well as applications in the power device field. Topics in the films/devices field included the development of Y-based high-temperature superconducting SQUID and filter and Nb-based low-temperature superconducting high-integration devices such as AD converter, router, and SFQ processor, and the development results aimed at developing ultra-fast, low-energy-consumption servers.

In the large-system applications field, the development progress, including verification test was reported, such as industrial applications of superconducting coil, magnet, motor, and power generator and power system applications of cable, SMES, transformer, and current-limiting devices.

At the closing on the third day, Prof. Satoshi Okuma (Tokyo Institute of Technology) summarized the reports in the physics/chemistry/vortex physics field, Dr. K. Iida (Leibniz Institute for Solid State and Materials Research Dresden) summarized the bulk field, Dr. M.P. Paranthaman (Oak Ridge National Laboratory) summarized the wires/tapes field, Dr. S. Benz (National Institute of Standards and Technology) summarized the thin film/devices field, and Dr. P. Tixador (Grenoble Institute of Technology) and Prof. T Coombs (University of Cambridge) summarized the large-system applications field. At the end, Yutaka Kiyokawa, Chairman of ISS2009 Steering Committee and Executive Director of ISTEC, gave the closing speech, and the symposium was successfully completed while hoping to meet again at the ISS2010, scheduled to be held for three days from November 1 (Mon.) to 3 (Wed.) in Tsukuba City.

Oral Session

Poster Session

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Feature Article: ISS2009 Topics - Physics and Chemistry -

Satoshi Okuma, Associate Professor
Research Center for Low Temperature Physics
Tokyo Institute of Technology

This page mainly introduces the invited lectures and oral presentations delivered in the physics/chemistry and voltex physics fields. Including the keynote lectures, about 60 presentations were delivered in the physics and chemistry field, and about 30 presentations were delivered in the voltex physics field. When classifying by materials, presentations related to iron-based superconductors accounted for about 50 percent in the physics/chemistry field, showing the increased activity in this research field. Besides such hot topics, many high-quality presentations were also given on cuprate superconductors and low T_c superconductors, which have been already studied since many years.

In the special keynote lecture, Dr. Hosono (Tokyo Institute of Technology) delivered a review report, including the latest data of his own, about the relation between the structures and properties of the five currently-known iron-based superconductors, the current status of thin film fabrication, and the topic of superconductivity induced by water. Dr. Iwasa (Tohoku University) reported on the electric field induced superconductivity in a perspective completely different from chemical doping. This is a unique research to develop and control superconductivity only by the electric field effect, where the electric field is applied to a charged dual layer comprising an insulator (strontium titanate) and an electrolyte so as to induce many carriers on the interface.

Physics/Chemistry: Regarding iron-based superconductors, Dr. X. Chen (University of Science and Technology of China) presented the evidence for the coexistence of superconductivity and spin density wave in Sm-1111-based and Ba-122-based superconductors on the basis of the experimental results of μSR and ARPES. Dr. C. H. Lee (AIST) reported the relation between crystal structures and superconducting properties, and the experimental results of phonon dynamics. Dr. Ogino (The University of Tokyo) introduced the design rules for the research of superconductor containing perovskite-type blocking layers, which was discovered by his group this year, and the latest research result that achieved T_c = 37 K by including vanadium in the blocking layer. In addition, Dr. Machida (Japan Atomic Energy Agency) theoretically showed that the nesting condition between Fermi surfaces, which originates from high two-dimensionality of this system, has an advantageous effect for a higher T_c. Dr. M. Shirage (AIST) reported the "Inverse Isotope Effect," where T_c increases as the mass of the iron atom increases in 122- and 1111-based superconductors. This result, however, is different from the report by Dr. X. Chen et al., and gave an impression of the complexity of iron-based superconductors. Dr. Kuroki (The University of Electro-Communications) delivered a detailed report about the current status of the research for the spin-fluctuation-mediated superconductivity theory based on the five-band model and the comparison with experiments, the relation between crystal structures and superconducting properties, etc. Regarding thin-film fabrication, it was a big news that Dr. Kawaguchi (Nagoya University) successfully fabricated a 1111-based epitaxial thin film with *Tc* exceeding 40 K.

Besides iron-based superconductors, Dr. Matsuda (Kyoto University) reported interesting phenomena in a heavy electron system URu_2Si_2, wherein the chiral *d* wave symmetry was determined by thermal

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conductivity measurements and thermal melting of flux-line lattice was found to occur even in a low temperature range below 1 K. Dr. Imai (The University of Tokyo) reported a remarkable result in the pseudo-gap region of an LSCO thin film that the onset temperature of superconductivity determined by the terahertz complex conductivity measurement is far below the temperature that had been previously reported by the Nernst effect measurement.

Vortex Physics: Dr. L. Civale (Los Alamos National Lab.) discussed general methods to improve the pinning property, which is important for superconductivity applications, from the view point of flux creep caused by thermal fluctuations. Dr. O. Auslaender (Stanford University) delivered an impressive report on the observation and control of a single flux using a magnetic force microscope. He observed that for the over-doped YBCO the magnetic flux line was extended when it was dragged, while for the under-doped sample the flux line was segmented and a flux state that reflects a pancake vortex was achieved. Dr. Nakajima (The University of Tokyo) introduced for the first time the columnar defect to an iron-based superconductor $BaFe_2As_2$ by heavy-ion irradiation and showed that the pinning property was improved.

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Feature Article: ISS2009 Topics - Bulk and Characterization -

Kazumasa Iida
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The bulk session included 32 contributions on RE-123 based compounds, five on MgB_2, one on RE_2CuO_4, and three on iron pnictides. Among them, RE-123 based materials accounted for all oral presentations including the plenary talk. As classifying the presentations by Y and RE on 123 families, there were 13 presentations on Y-based, three on Dy-based, nine on Gd-based, and three on Sm-based materials.

As classifying further the presentations on 123-based materials by their research contents, they are largely divided into three categories: process, characterization, and application; the process can be subdivided into two categories depending on the research purposes. A brief summary is given below.

At the plenary talk, P. Diko (Slovakia Science Academy) presented a guideline to achieve higher superconducting properties of YBCO based on detailed microstructural observations. He had successfully improved the critical current characteristics by modifying a temperature profile for oxygenation, which prevent from macro- and micro-cracks.

K. Iida (IFW-Dresden) *et al*. reported on the effect of ball milling Gd-211 powder on the superconducting properties. He reported that ZrO_2 impurities, which come from during the milling process, triggered inhomogeneous sample microstructure and therefore degrade the superconducting properties partially. However, he indicated that high performance of this material class can be obtained by minimizing the ZrO_2 contamination. Indeed a trapped magnetic field of over 1.5 T at liquid nitrogen temperatures has been achieved for the air-processed GdBCO bulk sample with 32-mm-diameter. M Izumi (Tokyo University of Marine Science) *et al*. reported that the pinning property was improved over a wider range of magnetic field by introducing soft magnetic Fe-B powders into the GdBCO bulk sample.

Addressing a clear strategy how to establish a cost-effective process for bulk superconductors becomes the key to accelerating application researches in the future.
R. P. Sawh (University of Houston) *et al.* reported that the unit cost of material can be reduced by replacing the conventionally-used Pt additive with nano-sized CeO_2 so as to improve the superconducting properties. However, a clear answer has not yet given to the reason underlying the use of nano-sized CeO_2 in place of micron-sized CeO_2. M. Miryala (RTRI) *et al*. also tried to reduce the unit cost of material by using Gd-based materials from which higher properties had already been obtained. Specifically:

1. they applied a batch process,
2. changed the fabrication atmosphere from hypoxic atmosphere to normal atmosphere,
3. reduced the Pt additive from 0.5wt. % to 0.1wt. % and added 1wt. % of CeO_2 for the reduced amount of the Pt additive, and
4. tried to fabricate ready-to-use Gd-123 and Gd-211 powders by themselves.

As a result, they had successfully achieved a substantial cost reduction while maintaining higher superconducting properties. They reported that up to 50-mm-diametral specimens could be fabricated. In addition, they reported that the key to the success of the batch process was the use of Nd-123/MgO thin film as the seed crystal. X. Yao (Shanghai Jiao Tong University) *et al*. also reported on a detailed research on using RE-123/MgO thin film as the seed crystal when fabricating a bulk sample. Using the Superheating

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Effect, they explained the high-temperature stability of RE-123/MgO thin film. These researches seem to contribute to the stable supply of low-cost bulk superconductors to users.

H. Fujishiro (Iwate University) *et al*. presented a detailed result of the research on the exothermic phenomenon of a bulk body during pulsed field magnetization and reported that the exothermic heat of the bulk body was adiabatic and the temperature distribution was homogeneous toward the thickness direction. As the application of a bulk superconductor is impossible without pulse magnetization, further advancement of this research is expected for the future.

Presentations of application researches on bulk samples were also delivered in the SA session in addition to the bulk session. T. Abe (JAXA) proposed the use of a Gd-based bulk body as the source of magnetic field for an atmospheric re-entry capsule. The atmospheric re-entry capsule needs to address two problems at the same time: suppressing the heat caused by friction and improving the deceleration capacity. He explained that these problems could be addressed by the interaction between the magnetic field and the weakly-ionized current velocity existing around the capsule. T. Kiyoshi (NIMS) *et al*. carried out an experimental fabrication of a magnetic flux concentrator using Gd-based bulk samples and reported on its properties. T. Oka (Niigata University) *et al*. presented a water purification unit by employing Gd-based superconductors.

Finally, the material development of bulk superconductor has almost been achieved, and a large bulk sample of 15 cm diameter is actually being fabricated and sold by Nippon Steel Corporation. In the application of superconductivity, our attentions tend to be drawn to the coated conductors, however, there are still some rooms available for bulk superconductors. I hope some applications employing bulk superconductors will emerge near future and expect that many presentations of research results will be delivered at the next ISS in 2010.

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Feature Article: ISS2009 Topics - Wires/Tapes/Characterization -

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The field of "Wires and Tapes" comprised eight oral presentation sessions and one poster session. In the oral sessions, a total of 19 presentations were delivered, including seven special presentations and one keynote lecture in the memorial session for Dr. Suenaga of Brookhaven National Laboratory. In the poster session, there were 90 presentations among which YBCO-coated conductors were still dominant with 67 reports, followed by 14 on MgB_2 and nine on BSCCO-tape materials. The major contents are summarized as follows;

For the development of YBCO-coated conductor, I summarized the latest development trends in Japan at the keynote lecture (PL-3), in which I reported on the current status of development and the plans for the future. The Development of coated conductors has been promoted with an expectation of carbon dioxide emissions reduction, which has been drawing attention in the recent years. In Japan, the development has been focused on tapes using IBAD layers. Regarding the structure using $Gd_2Zr_2O_7$ as the IBAD layer, a 500-m-long wire exceeding 300 A/cm-width had already been fabricated by Fujikura Ltd. and SWCC Showa Cable Systems Co., Ltd. in the collaborations with ISTEC. After that, the development has shifted to the use of IBAD-MgO that allows low-cost, high-speed fabrication. The latest result is that Fujikura Ltd. has successfully developed a 1-km-long, high-orientation buffer layer at an extremely high speed of 1,000 m/h. Using a part of this buffered substrate layer, a 250-m-long tape was fabricated by forming superconducting layers by using the PLD method, and a high I_c value of 640 A was obtained as an average I_c value, although there were some portions with I_c lower properties. As a related presentation, Dr. Iijima (WT-14) reported the development result of hot-wall-type PLD system, along with the development of the abovementioned IBAD method. The feature of this method is that a high crystallinity can be obtained even at high speeds by optimizing a deposition condition that is close to a thermally equilibrated condition. By making full use of this feature, they achieved a high I_c value of 1,000 A, while also trying to increase the speed by applying a tandem laser system. ISTEC group introduced a planarization technology in the MOD method for metal substrates as a cost-reduction technology that supports IBAD-MgO. They successfully achieved a planarization of Ra < 2 nm by using Gd-Zr-O, which is effective as the bed layer for formation of IBAD layer. On this planarized surface, they formed buffer layers and superconducting layers and confirmed a high J_c value (up to 2.5 MA/cm^2) that was equivalent to conventionally obtainable values. The further details were reported by Mr. Takahashi (WT-17). As the latest APC technology, dispersion of BZO nanoparticles has been realized in the TFA-MOD method to improve the properties in a magnetic field. By the uniformly (including the thickness direction) dispersed BZO particles, a field-angle-dependent, isotropic behavior was confirmed as the feature. Regarding this topic, Dr. Yoshizumi (WT-10) reported the details of the growth mechanism, and Dr. Miura (VP-3) reported on the improvement of an irreversible magnetic field under an ultrahigh magnetic field that was evaluated in the jcollaboration with Los Alamos National Laboratory.

As for reports from abroad, Dr. A. Otto (WT-9) of American Superconductor (AMSC) Corporation delivered a report on the TFA-MOD tapes based on textured metal substrates. Recently, they have successfully fabricated a 500-m-long tape with 250 A/cm by. Dr. M. Paranthaman (WT-18) of Oak Ridge National Laboratory reported on the development progress of all MOD-process for cost reduction by introducing a Ce-Zr-O/LTG intermediate layer by using the MOD method and the development results of

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LMO-MgO composite material for the purpose of pinning-introduction. This is an idea to introduce tiny defects into the upper superconducting layer by dispersing MgO, which has a low matching property, inside LMO that has a high crystal lattice matching. Currently, up to the stage of fabricating an textured film has been confirmed, and its properties are now expected. From Europe, Dr. A. Usoskin (WT-15) of Bruker HTS GmbH explained about the introduction of a series of large equipment for ABAD-PLD tapes, and they start ed up the equipment for the development for the 2-km-long tapes. Prof. X. Obradors (WT-11) of CSIC, Spain, explained the result of speed improvement for film growth under a low-pressure environment as a fundamental consideration for the TFA-MOD method. Further, he clarified the relation between the pinning force and the stress around the pinning material.

Among other reports, Prof. Doi (WT-12) of Kagoshima University achieved a tensile strength of 700 MPa by bonding with SUS in the development of wires using a textured Cu metal substrate and obtained a J_c value of 4.5 MA/cm^2, even though it was only a 270-nm thin film. Dr. Y. Shingai (WT-13) of Sumitomo Electric Industries, Ltd., reported on the wide-width process for textured metal substrate, and Prof. Yoshida (WT-19) of Nagoya University reported the existence of strong *c*-axis correlated pinning in the PLD films. Regarding evaluations, Dr. Sugano (WT-23) of Kyoto University and Dr. D. Laan (WT-24) of NIST delivered presentations on mechanical strength concerning property variations caused by stress and reported unique phenomena under the influence of a magnetic field. In addition, Dr. F. Gömöry (WT-26) reported on the evaluation of AC losses concerning various types of tapes.

As for MgB_2 wires, Dr. G. Grasso (WT-1) of Columbus Superconductors SpA obtained J_e = 180 A/mm^2 (20 K, 1.2 T) by C-doping, react & wind method, and the company provided a 150-km-long wire for an open-type MRI magnet. Dr. Tokano (WT-2) of National Institute for Materials Science reported that they obtained J_c value up to 10^5 A/cm^2 (4.2 K, 10 T) by densification and optimization of the multi-filament condition and achieved properties equivalent to that of Nb-Ti as the first time.

As for BSCCO tapes, Dr. Osabe (WT-6) of Sumitomo Electric Industries, Ltd., reported on the current status of DI-BSCCO wires; they achieved the world's highest value of 236 A (548 A/cm) with a short length and an $I_c \times L$ value of 368 kA m with a longer length. Prof. Nakamura (WT-8) of Toyohashi University of Technology reported on the loss reduction by barrier material and twist for BSCCO tapes and pointed out that J_c would decrease due to the geometrical relation.

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Feature Article: ISS2009 Topics
- Films, Junctions and Electronics Devices -

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At the Films, Junctions and Electronic Devices Session, there were 18 oral presentations and 46 poster presentations. It seemed that the slightly fewer number of presentations compared with previous years was caused by a fewer number of presentations for low-temperature digital circuits in Japan. It may primarily be because of the suspension of experimental device fabrications for about half a year since November last year, as the ISTEC Niobium Process was relocated to the National Institute of Advanced Industrial Science and Technology. However, I had the impression that the quality of presentations was higher than previous years. From among the presentations, some have been selected and summarized as follows.

A Canadian quantum bits venture company, D-Wave Systems Inc., has raised a large capital investment and currently employs 55 staff members. With a system accumulating 128 quantum bits as the final target, the company is now developing an eight-quantum-bit system. For the eight-quantum-bit system, they are fabricating 64 DA converters by using 1,500 Josephson junctions (JJ) and the niobium process with the minimum line width of 0.25 μm. They are using planarized SiO_2 interlayer dielectric films and four niobium layers. However, there were no reports on quantum bit movement.

Hypres Inc., a US venture company specializing in the niobium device business, is developing systems centering around AD converters with almost 40 staff members. This time, the presentation was related to the currently developing correlator targeted for astronomical observation and telecommunication applications. Hypres makes a concept as Hybrid Technology and Hybrid Temperature $(HT)^2$ and is involved in the development of a system that correlates and parallelizes the AD-converted data from a superconducting multi-chip module and outputs the data at a low speed; it then processes the data using a room-temperature semiconductor FPGA, before sending the data to a semiconductor DSP. The company is trying to achieve an earlier practical application of a superconducting system by combining it with room-temperature semiconductors.

NIST is developing a JJ that uses NbSi for its tunnel barrier. The feature is that I_c and R_n can be controlled independently by changing the proportions of Nb and Si. This method allows the fabrication of an optimal JJ for Josephson voltage standard and digital circuits. NIST reported that a good measurement result was obtained by using this JJ to fabricate an SFQ shift register designed by Northrop Grumman Corp. The National Astronomical Observatory of Japan reported on subgap leak of niobium JJ, which will be used for submillimeter-wave detection in the future. They described that an AlN barrier showed a remarkably lower leak than the current mainstream AlOx barrier at a cryogenic temperature of about 0.5 K; a part of the subgap leak could be well-explained with a model using a complex gap; the subgap leak deteriorated because of impurities (Fe, Cr, etc.) contained inside the Al film; and that the quality of niobium film should be improved in order to substantially improve the subgap leak.

CNR (Italy) arranged SSPDs (Superconductive Single-Photon Detectors) in parallel and improved the efficiency with a method that selects the SSPDs by a cascade switch. The National Institute of Advanced Industrial Science and Technology applied an STJ (Superconductor Tunnel Junction) detector to the TOF (Time of Flight) analysis of proteins and successfully detected heavy molecules that could not be measured with existing detectors. As this method also identifies the valence, different molecules with the same mass can be distinguished.

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Tokyo Institute of Technology, IFW (Germany), Nagoya University, and Tokyo University of Agriculture and Technology reported on thin-film forming of iron-based superconductors. Among these reports, the highest critical temperature was 41 K, achieved by Nagoya University. However, the film-forming speed is very low: only 15 nm/h. Further researches are expected to determine whether it is an intrinsic difficulty of forming iron-based thin films.

Kanazawa Institute of Technology presented on medical systems using low-temperature SQUID. Currently, 130 SQUID magnetic encephalography systems are used in the world to obtain valuable information that cannot be available with other systems. In addition, more beneficial information can be obtained by combining it with MRI. A magnetic encephalography system specifically designed for children has provided a result that shows that a child's response time during language learning greatly differs from that of an adult. With a spine measurement system, accurate diagnoses can be performed even when the damaged part cannot be identified only from MRI, thereby eliminating the need for dangerous examination by needle insertion. Toyohashi University of Technology reported on an experiment to apply a high-temperature SQUID to contamination inspection of lithium batteries. Contamination particles of diameters 50 μm or less are a big problem for batteries; however, they cannot be detected by X-rays. Thus, the university developed a device that closely arranged the SQUID and the specimen with a distance of 1.3 mm and successfully detected contamination particles of 50 μm.

ISTEC described the potential for increased sampling speeds by developing a high-speed AD converter for a real-time oscilloscope and by improving the process. The National Institute of Advanced Industrial Science and Technology successfully increased the output of a pulse-driven AC voltage standard device by using the high-speed optical input technology for superconducting circuits, which was developed by ISTEC.

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Feature Article: ISS2009 Topics - Large Scale System Applications -

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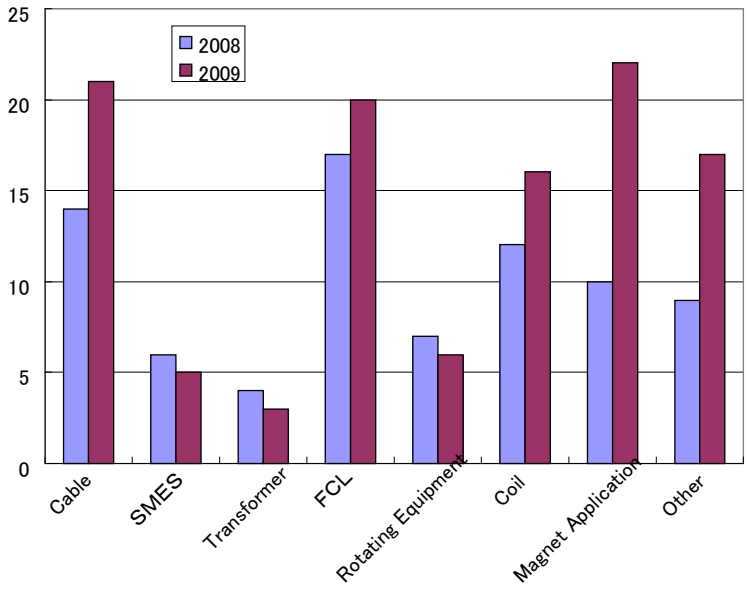
The large scale system applications field included 28 oral and 82 poster presentations for a total of 110 reports. The number largely surpassed the number in the previous year (81). One factor for this increase may be improved performance of Coated Conductors such as critical current and longer length, allowing for its applications to power devices. When classifying by technological fields, there were 22 reports on magnet applications, 21 on cables, 20 on FCL (fault current limiter), 16 on coil fabrications, 6 on rotating equipment, 5 on SMES, 3 on transformers, and 17 on other applications (excluding the plenary). The following is the report on topics by individual technological fields.



Number of reports classified by technological fields of SA

As for Japan's project "Materials & Power Applications of Coated Conductors, M-PACC ," a lecture entitled "Development of YBCO Power Devices in Japan" was delivered at the plenary held on the first day, which reported the outline of the project and the progress in the development of SMES, cables, and transformers. The development of each device is currently carried out to achieve the interim target of the project for fiscal 2010 (PL-6).

Regarding cables, the "Tres Amigas" project in the US was spotlighted. This project will include a demonstration experiment of 5-GW power transmission in New Mexico with an aim to link the North American power grids, which are dispersively located in the East, West, and Texas regions, using DC cables (PL-2, SA-20). From Europe, research results were reported, such as cable cooling aimed at the demonstration experiment of 50 kV and 6-km-long cables in Amsterdam. This experiment will start in 2011, which is the 100th year since the discovery of superconductivity (PL-5). From Korea, the KEPCO Cable Project was explained with more detailed information than in the previous report. By 2011, this project will

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introduce a 500-m-long, 22.9-kV 3-phase cable into a substation to carry out the experiment (SAP-1).

As for FCL, 22.9-kV, 3-kA, and 630 A current-limiting devices will be developed along with the abovementioned KEPCO Cable Project so as to carry out a demonstration experiment at the same substation (SA-6). In Europe, FCL is drawing attention from the viewpoint of inter-country linkage and response to the Smart Grid, and "ECCCFLOW" project has been launched. The feature of this project is that it is carried out as a joint project by 15 companies, including five power companies led by Nexans, and it is independent of the government (PL-5).

As for rotating equipment, US and Europe delivered reports at the plenary held on the first day in the form of superconductivity applications to large-scale wind-power generation. For a large-capacity wind power generator of 5 MW or more, the nacelle weight will inevitably increase when a conventional synchronous generator is used. They stated that downsizing can be achieved by the use of superconducting generators (PL-1, PL-5). The University of Tokyo reported the result of a design study that they conducted by electromagnetic analysis for a 10.3-MW-class synchronous generator (SA-21).

There were active reports on the design and experimental fabrication of coils using CCs. SuperPower Inc. used its original wire for experimental coil fabrication and achieved a central magnetic field of 27.4 T by applying a backup magnetic field of 4.2 K, 19.9 T (SA-1). This report was followed by a series of other study reports describing that magnets could be downsized while strengthening the magnetic field by the use of CCs (SA-12 etc.).

As for magnet applications, there were many researches on slurry separating systems using strong magnetic field for water purification. Osaka University reported that a COD (chemical oxygen demand) of 500 ppm in discharged water was reduced to 100 ppm or less (SA-24), and Niigata University reported on the purification of discharged water from a garbage incineration facility (SA-25).

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Feature Article: ISS2009 Topics - Memorial Session for Dr. Suenaga -

Osamu Horigami
Vice President
Cryogenic Association of Japan

At this year's ISS, a special session was held to commemorate the late Dr. Masaki Suenaga, who suddenly passed away at the age of 71 in February this year. Dr. Suenaga joined Brookhaven National Laboratory (BNL) immediately after receiving his PhD from the University of California, Berkeley in 1969 and pursued researches on superconducting materials at BNL all through his life; he is well known for his world-leading achievements and his personality.

Prof. D. Larbalestier's lecture - the deceased holding a plaque received from ASC last year
(photographed by Mr. Hobiki, ISTEC)

Although it was held concurrently with the poster session from 6 p.m., an audience of more than 50 people was intently listening to the lectures while cherishing the memory of the deceased.

At the lecture session, seven close acquaintances of Dr. Suenaga delivered their lectures.

The session was hosted by Dr. D. O. Welch, a colleague of Dr. Suenaga at BNL, and Dr. Yutaka Yamada of SRL, who had learned much from the deceased for many years in the research of superconducting materials.

After the host introduced a brief biography of the deceased, the first son of Dr. Suenaga, who has been living in Yokohama City after graduating from a university in the US, gave a brief address of gratitude. The content of his address included appreciative words such as "I am very grateful for including my father's session in the valuable schedule of the symposium" and "My father was able to continue his effort over many years, thanks to the support from all of you."

The first lecturer, Prof. Tachikawa of Tokai University, commented on his personal relation with the deceased immediately after Dr. Suenaga joined BNL and recollected fond memories from research aspects. He also commented that, from 1973 to 1999, Dr. Suenaga gave guidance to nearly 17 researchers dispatched from Japan to BNL; he also shared some valuable pictures of him along with the deceased

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when he was young. After that, he delivered a lecture entitled “High-Performance New Nb_3Sn Wires With Sn-based Alloys” and reported mainly on the fabrication process and properties of Nb_3Sn by the jerry roll process.

Dr. Welch delivered a lecture entitled “Mas Suenaga and the Science of Superconducting Materials.” He also touched upon the contribution made by the deceased to the development of power transmission cables using Nb_3Sn, which was under development by BNL in around 1974 and the meaningful contributions to the understanding of various factors from the aspect of materials science that affected the properties of superconducting materials from then on. Many of his accomplishments from the early period to the present were introduced, such as: in 1980, Dr. Suenaga published a specialized book entitled “Filamentary A15 Superconductors” as the chief editor, and he played an active role as the representative of the US in the Japan–US Joint Research on AC Losses that was started in 2005.

Dr. Kenichi Sato, Sumitomo Electric Industries, Ltd., delivered a lecture entitled "BSCCO Research Collaboration with Dr. Mas Suenaga," which started with appreciative words for one of his most respected researchers and introduced some of the many research papers presented by the deceased, i.e., Grain Boundary Problem in BSCCO, Phase Transition of Vortex from Solid to Liquid, Pinning, Microstructure of Crystal and its Relation with Grain Boundary and Transport Current, AC Losses, and Heavy-ion Irradiation Effect; all the papers clearly demonstrated his pioneering research achievements produced by his excellent insight into the nature of materials. Dr. Sato gratefully commented that Dr. Suenaga made meaningful contributions to the advancement of superconducting material development, while also implying the limit of practical applications.

Prof. D. Larbalestier of the National High Magnetic Field Laboratory, Florida State University, delivered a lecture entitled “Some Reflection on the impact of Masaki Suenaga on the Science and Application of Nb_3Sn.” He commented that it was a historical encounter at the Rutherford Appleton Laboratory in 1973 that Sir Martin Wilson referred him to a research paper titled “Superconducting Properties of Multifilamentary Nb_3Sn Made by a New Process” (Applied Physics Letters, 1972) written by the deceased; he mentioned that they had been close family friends since then for 36 years, while he was learning many things from the deceased. He also stated that Dr. Suenaga was a good lifelong rival and expressed gratitude for helping his growth. Finally, he commented that Dr. Suenaga was awarded at the ASC held last year for his achievement over many years.

After that, Dr. K. Marken, who is currently working at the Los Alamos National Laboratory, delivered a lecture entitled “Dr. Suenaga’s work in YBCO and Coated Conductors” and gave an interesting report on the achievement of the deceased from a quantitative perspective. He reported on Dr. Suenaga’s extensive activities by explaining that the published abstracts of the papers presented by the deceased, which amounted to a thickness of 28 mm even when limiting only to Y-based materials, brought up various topics; he carried out collaborative researches with more than 130 researchers across 41 institutions around the world; his research themes covered Material Synthesis, Detailed Micro-structural Studies, Conductor Processing, Measurements of Transport and Magnetic Properties, Flux Pinning and Creep, AC Losses, Substrate Effects on Properties, etc.

Prof. Iwakuma of Kyushu University, who had a very close relation with the deceased in the Japan–US Collaborative Research on AC losses, reported on the results of the collaborative research in his lecture entitled “AC Loss Properties of YBCO Superconducting Tapes with A Magnetic Substrate.” In addition to the research content, he commented on various events related to the joint research by showing many pictures. He also commented on Dr. Suenaga’s filial devotion to his parents: when he was staying in Fukuoka, he visited his elderly parents at his family home in Shimonoseki City from time to time.

The final report was delivered by Dr. Yoshizumi of SRL. He reported on the content of the collaborative research carried out with the deceased for several years in the DOE Project, which started in 2003, while he

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was staying at MIT from 2001 to 2006, in his lecture entitled “Development of Conversion Process in Ex-situ BaF_2 Process.” He explained that Dr. Suenaga had also contributed largely to this field, such as by clarifying the YBCO growth mechanism in the BaF_2 process and proposing a unique fabrication process.

It is also worth noting that many of the presenters commented on his tender-hearted personality.

Finally, prompted by the host, Dr. Suenaga’s first son expressed his appreciative words:

Mr. Ken Suenaga, the first son, expressing his gratitude at the end
(photographed by Mr. Hobiki, ISTEC)

“I would like to thank you again for participating in my father’s session, instead of visiting the attractive poster session. If you would not mind my asking a personal wish, I would appreciate that all of you will advance the superconducting technology by further enhancing international researches, which I am sure my late father is also wishing for.”

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Feature Article: Superconducting Microwave/Optical Devices
- Technological Trend of Superconducting Microwave/Optical Devices -

Shigetoshi Ohshima, Professor
Department of Electric Engineering
Graduate School of Science and Engineering, Yamagata University

Information on applications such as superconducting filters, terahertz detection superconducting devices, and superconducting receivers for the ALMA project can be obtained by referencing other articles in the Superconductivity Web21; therefore, I would like to describe the recent researches on applying superconducting filters to ultra-wideband (UWB) communication and on the ideas for efficient utilization of radio wave resources.

The USA had taken the lead in using superconducting filters for cell towers; then, China followed suit, and the situation seems to have been almost settled for the time being. Although the system does not seem to have any problems in performance, reliability, and durability, it seems that new infrastructure development is difficult in Japan and Europe, where economic conditions are deteriorating, and that practical application is almost impossible. Then, don't the superconducting filters have any hope for practical application in the future? Yes, I believe possibilities still exist. One possibility is the application to UWB communication. UWB communication is a radio communication that uses frequency bands of 500 MHz or higher (1.5 GHz or higher in some cases). It was originally developed as a military technology, and its commercial use was granted by the Federal Communications Commission in 2002. In the USA, this communication system can be used without any special license. It allows short-distance, large-capacity, and high-speed communication with high tolerance for interference, and it is said to become the centerpiece of high-speed radio communication in closed spaces. Currently, the standardization of the transmission method and researches for devices such as antennas and filters are being carried out around the world. In Japan, the Ministry of Internal Affairs and Communications specifies 3.4–4.8 GHz and 7.25–10.25 GHz bands as the frequency bands for UWB communication (Fig. 1). [1] These frequency bands, however, have already been used for various services; therefore, it is important to prevent mutual interference of the radio waves. The research results until now clearly show that a superconducting band-pass filter is an optimal device to prevent mutual interference. Thus, the superconducting band-pass filter has been spotlighted for its application to UWB, and there are an increasing number of reports related to the design of superconducting filters with a bandwidth of 500 MHz or more. Currently, various types of superconducting filters have been proposed by researchers in China, Korea, and Japan, and they are coming closer to the realization of high-performance filters. I would like to expect future advancement of these researches.

I would also like to describe the efficient utilization of frequency resources. In the USA, it was Superconductor Technologies Inc. (STI) that had implemented superconducting filters in practical applications. Taking a look at the STI website[2], it is noticeable that their insistence appears to have changed recently. They used to put emphasis on the performance of superconducting filters; recently, however, they are strongly appealing for the securing of frequency resources. In the USA and Europe, there are businesses that sell frequency resources to the public. The price for a 52-MHz bandwidth on a 700-MHz frequency band is said to have climbed to 19 billion dollars. On the basis of this price, the price for a 6-MHz bandwidth is 2.2 billion dollars. STI is appealing that it is a loss of national profit if such expensive frequency resources are not utilized more efficiently. Figure 2 shows the difference in the efficiency of frequency utilization between the use of a conventional filter and a superconducting filter. As shown in (a), only 25 effective resources are available with the conventional filter system (i.e., 88 million dollars per resource).

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When using a superconducting filter system, the guard band can be narrowed to increase the effective resources to 27. Thus, only in this 6-MHz bandwidth, a profit of 176 million dollars is gained. By using a superconducting filter system in this way, it is clear that the frequency resources can be utilized more efficiently. I wonder if this kind of stream could emerge in Japan.

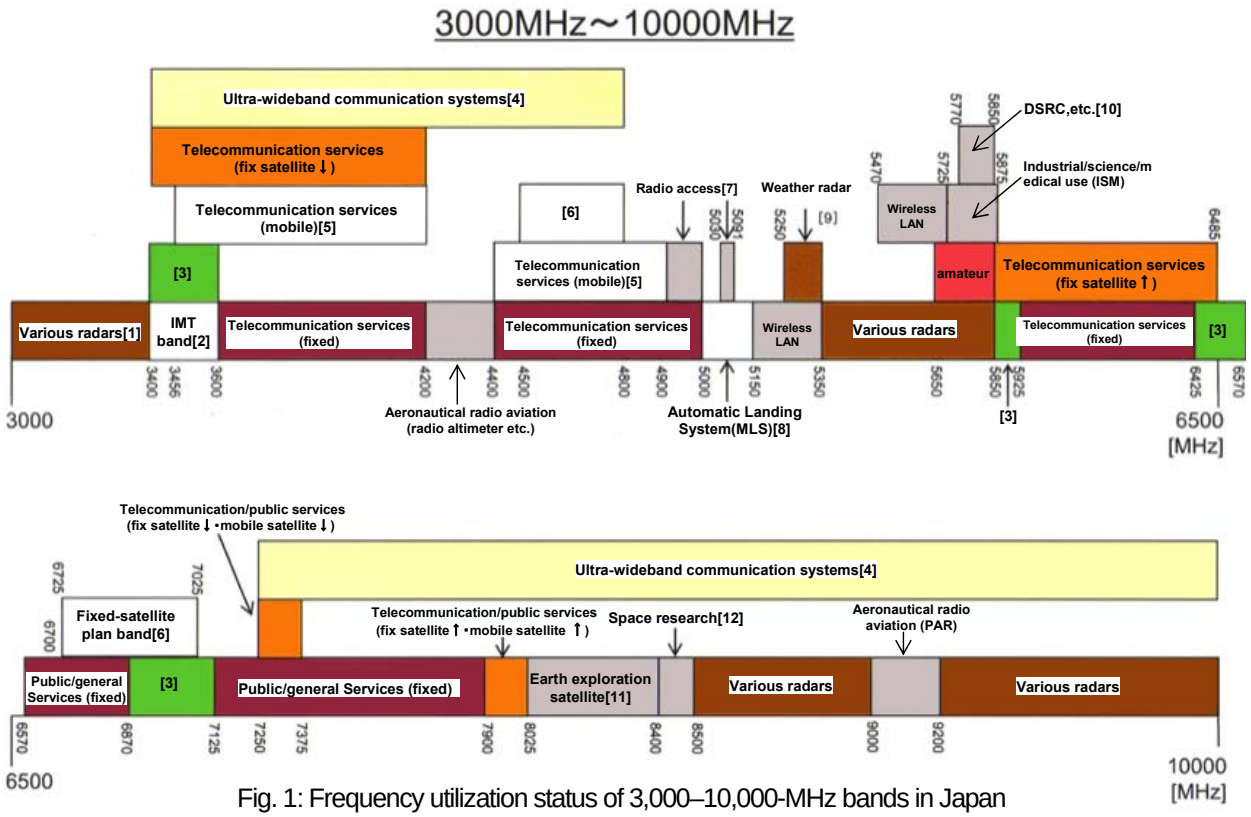

Fig. 1: Frequency utilization status of 3,000–10,000-MHz bands in Japan

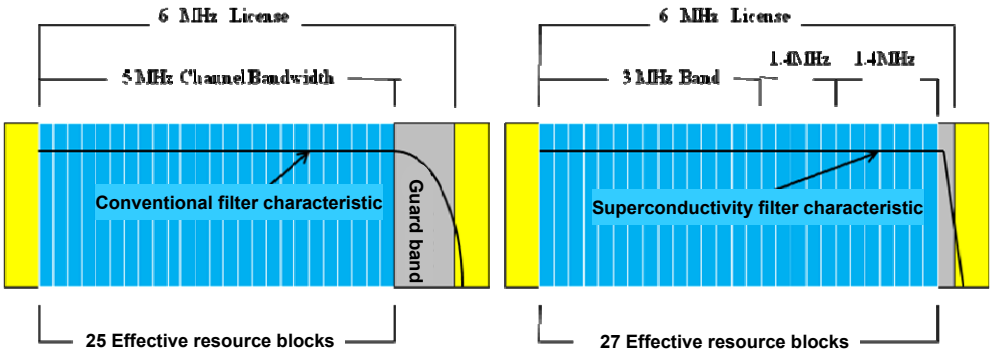

Fig. 2: Magnified view of the effective resource blocks when using a superconducting filter

Reference:

1) Ministry of Internal Affairs and Communications HP:
http://www.tele.soumu.go.jp/j/adm/freq/search/myuse/use/index.htm
2) STI Web: http://www.suptech.com

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Feature Article: Superconducting Microwave/Optical Devices - The current status of the technology to increase the power-handling capability of segmented microstripline resonator filters -

Atsushi Saito, Associate Professor
Graduate School of Science and Engineering, Yamagata University

Along with the rapid popularization of information-communication terminals (mobile phone etc.), the next-generation, high-speed, and large-capacity communication technology and its standardization are under consideration. This next-generation (fourth generation) communication technology is called IMT-Advanced, as it is a successor to the ongoing IMT-2000 (IMT: International Mobile Telecommunication), and it requires a relatively wide frequency band; therefore, it is important to efficiently utilize the frequency resources. Introduction of a superconducting front-end system is effective as a hardware-assisted solution, and receive filters have reached to practical applications in the US and China. Meanwhile, research and development of superconducting transmit filters is also being carried out. Recently, a superconducting transmit filter using a circular resonator was introduced on a trial basis in China, and it is entering the stage of practical application. Research challenges for realizing an optimal superconducting transmission filter are: 1) increased power-handling capability, 2) reduced distortion, 3) improved skirt characteristic, and 4) downsizing. The reality is that the increased withstanding power is barely achieved.

Thus, our laboratory is now carrying out a research on the relation between the configuration and the withstanding power property of a microstripline (MSL) resonator, which allows to achieve steeper skirt characteristic in a relatively small size by using multi-pole resonators. With a conventional MSL, high-frequency current concentrates at the edges of the resonator (Fig. 1 (a)), and when the current exceeds the critical current, the resonator causes normal conducting transition and does not maintain the filter property. Therefore, we are proposing a segmented MSL resonator intended to achieve a reduction in the maximum current at the edge portions, which should be accompanied by the improvement of power-handling capability, by dividing the resonator along the width direction so as to disperse the high-frequency current toward the inner part (Fig. 1 (b)). From magnetic field simulations and experiments carried out until now, it has been confirmed that the power-handling capability of a filter using a segmented MSL resonator is improved by 5 dB when compared with a conventional MSL filter.

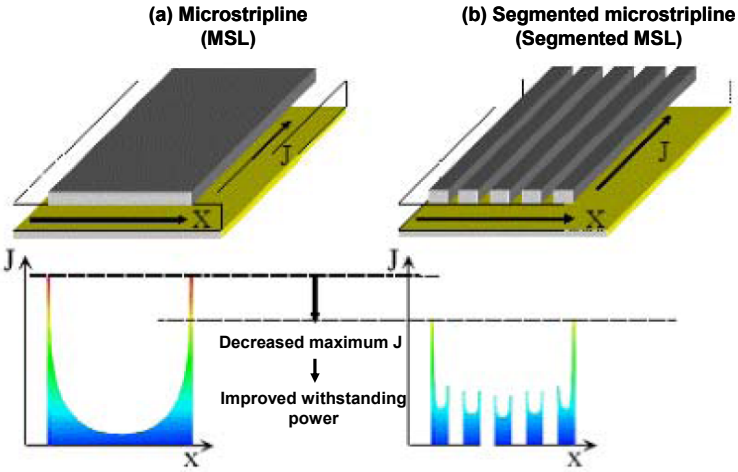

Fig. 1 Schematic view of microstripline and segmented microstripline, and the current distribution in the width direction

Figure 2 (a) shows a schematic view of the seven-stage segmented MSL resonator filter fabricated in joint research with Fujitsu Laboratories Ltd. In the picture, the side walls and top cover are removed to show the internal structure. We used a double-faced YBCO thin film (thickness: 700 nm), which was formed on a

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MgO single-crystal substrate, in the fabrication of the filter. The size of the substrate is 25 mm × 50 mm, which corresponds to only two poles for circular resonators; however, seven poles can be arranged by using segmented MSL resonators. Each resonator is evenly segmented along the width direction into 13 strips using 40-μm slits (Fig. 2 (b)). Figure 3 shows the frequency characteristic (a) and the power-handling capability (b) of the seven-pole segmented MSL resonator filter. The measurement temperature is 70 K. The frequency characteristic indicates a good agreement with the simulation, and a steep skirt characteristic is obtained. In addition, the power-handling capability of 2.7 W is obtained.

Since further improvement in the power-handling capability is required for practical application, we are now optimizing the configuration of the resonator, while considering uneven segmentation in addition to the even segmentation that we have used previously. The power-handling capability can be further improved by considering a patterning method to reduce the damage to the superconducting thin film and by using thin/thick films as the filter materials into which artificial pinning centers are introduced. We are planning to conduct an active research so that the abovementioned results of our efforts will be adopted into IMT-Advanced.

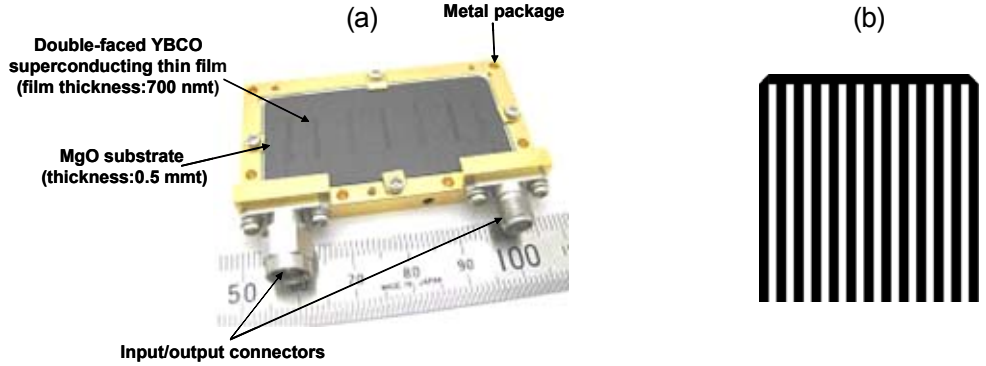

Fig. 2 Schematic view of a seven-pole segmented microstripline resonator filter (a), and schematic view of segmented MSL resonator (b)

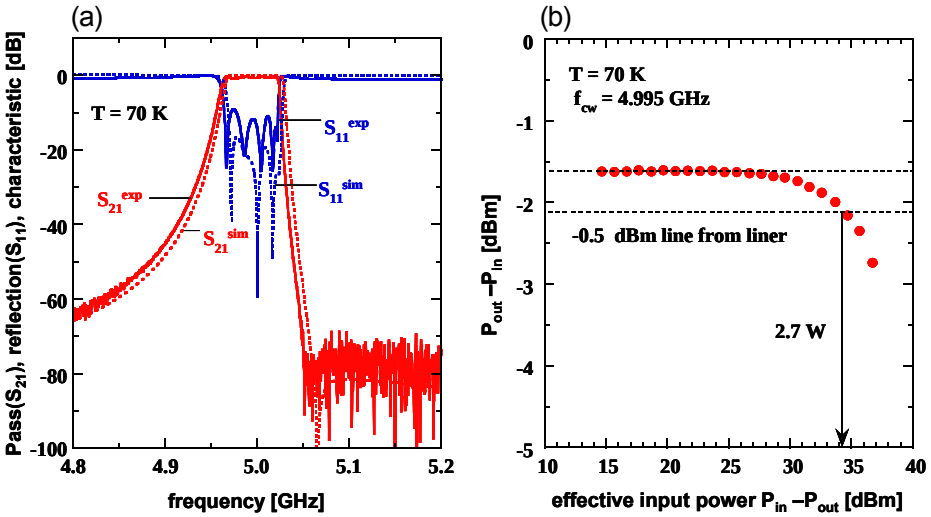

Fig. 3 Frequency characteristic (a) and power-handling capability (b) of the seven-pole segmented microstripline resonator filter

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Feature Article: Superconducting Microwave/Optical Devices - Development of Superconducting Detectors for Observing Cosmic Microwave Background Radiation -

Chiko Otani
Terahertz-wave Research Group,
RIKEN Advanced Science Institute

While we frequently hear the phrase that “Our universe has started from the Big Bang”, the “inflation” is thought to be occurred at which the size of the universe increased exponentially before the Bang. Because “the standard theory” of elemantary particle physics cannot predict the inflation, experimental and theoretical researches are required for reaching an ultimate theory of fundamental physics. Cosmic Microwave Background (CMB) is the electromagnetic radiation generated when the universe became transparent for radiation (380,000 years after birth), and the traces of the primodial gravitational waves during the inflation are inscribed as a specific polarization pattern in the CMB radiation (the pattern is called as “polarization’s B-mode”). Thus, extremely sensitive measurements of the spacial distribution of the CMB polarization allow observational researches of the inflation period, and the physics in extremely high energy, which is impossible to reach by ground experiments, can be investigated by the comparison between observational results and the theoretical predictions.

We have started a project (scientific research fund/new academic field “the "Physical Origin of the Universe Viewed through the Cosmic Background Radiation" supported by the MEXT Grant-in-Aid for Scientific Research on Innovative Areas in FY2009, to find the “polarization’s B-mode” as well as to develop detectors for achieving extremely sensitivie CMB polarization observations by the future observation satellites (http://cbr.kek.jp/). We are conducting a collaborative research and development with High Energy Accelerator Research Organization (KEK), National Astronomical Observatory of Japan (NAOJ), and Okayama University, aiming at the realization of a millimeter-wave detector array for the CMB observations as well as a submillimeter-wave (terahertz wave) detector array for cosmic infrared background (CIRB) observations. Our goal is to develop 1,000-pixel-class imaging detectors (sensitivity down to 10^{-18} W/√Hz) for CMB and CIRB observations. For these detection devices, we will utilize Cooper pair breaking inside the superconductor and we plan to promote the developments of superconducting tunnel junctions (STJs) as well as a superconducting microwave kinetic inductance detectors (MKIDs).

For the STJ detectors, we are developing detection devices to utilize the absorption by a superconducting thin film with the impedance match between the film and space (thin-film-matching STJ detector). In the detection, we measure the additional current by the excited quasiparticles. We have already succeeded in conducting experiments to prove the detection principle by using Nb and Al superconductors, and confirmed their broadband characteristics[1]. In contrast, MKIDs read out the decrease in kinetic inductance through the change in the alternating-current (AC) characteristic. The change is caused by the decrease in the number of Cooper pairs that originates from the incoming radiation. The principal characteristics of MKIDs is that the fabricattion processes and the readout of the signal from a large-scale array are relatively easy. In that sense, the detector can be the superconducting detection device in the near future[2].

Reference:

1) S. Ariyoshi *et al*., *Appl. Phys. Lett.,* 95, 193504, 2009.
2) P. Day *et al*., *Nature*, 425, 817, 2003.

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Feature Article: Superconducting Microwave/Optical Devices - The Current Status of the Atacama Large Millimeter/Submillimeter Array (ALMA) Project -

Takashi Noguchi
Advanced Technology Center
National Astronomical Observatory of Japan

ALMA (Atacama large millimeter/submillimeter array) is a large-scale raperture synthesis radio telescope, which is under construction at the Atacama highland, 5,000 m above sea level, in the northern Chile, South America. ALMA will have 80 antennas spread over distances of up to 18 km, and operating as a single, giant telescope to provide an angular resolution as high as 1/100 arcsecond, which is 10 times better than that of the Hubble Space Telescope. In addition, the total effective collecting area of the 80 antennas is as large as 7,200 m^2, which is about 100 times larger than the light collecting power of existing 10-m-class submillimeter-wave telescopes. Currently, the construction of the ALMA telescope is in progress satisfactorily (Fig. 1). When completed at the end of 2011, it is expected to become a telescope with the world's highest sensitivity and resolution in the millimeter/submillimeter waves ranging from 30 to 950 GHz (10–0.3 mm in wavelength).

Fig. 1 Three antennas of diameter 12 m installed at the Atacama site, 5,000 meters above sea level. The antenna at the far left is made in Japan.

ALMA has the observation frequency ranging from 30 to 950 GHz which is divided into 10 frequency bands, and five laboratories in Japan, the US, and Europe share the production of receivers for each frequency band. The National Astronomical Observatory of Japan is taking responsibility for building receivers for three frequency bands: 125–163 GHz (band 4), 385–500 GHz (band 8), and 787–950 GHz (band 10), for a total number of 240 receivers. ALMA's receivers that cover 80 GHz (band 3) or higher use SIS mixers based on Nb/AlOx/Nb-type superconducting tunnel junctions.

For the ALMA band 4 and 8 receivers, the development phase has successfully completed by utilizing the existing technologies on the fabrication of SIS junction elements and building low-noise receivers. The first receiver for ALMA band 4 was shipped out in September last year, and the project now moves into the production phase.

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In contrast, to achieve ALMA band 10 it is definitely required to introduce several new technologies, and the project is currently in the development phase, which mainly focuses on the development of these technologies. As the frequency of ALMA Band 10 exceeds the gap frequency of Nb (~690 GHz), it is necessary to introduce a low-loss superconductor in place of Nb in order to realize low-noise receivers. NbTiN is regarded as a promising material for the signal transmission line for this frequency band due to its high transition temperature of ~14 K and low surface resistance. Figures 2 and 3 show the structure of an SIS mixer for ALMA band 10, which was fabricated in cooperation with the Kobe ICT Research Center, National Institute of Information and Communication Technology, and the obtained receiver noise temperature[1], respectively. This result demonstrates the world's best receiver performance in this frequency band and indicates that the ALMA band 10 receivers, which have been considered to be difficult to realize, it is basically possible to comply with the ALMA specifications.

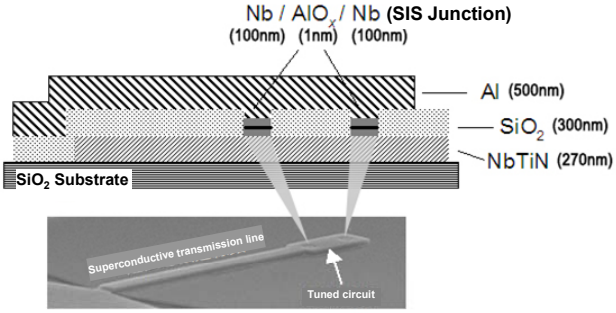

Fig. 2: Cross-sectional structure of Band 10 SIS device (top) and image of SEM (bottom).

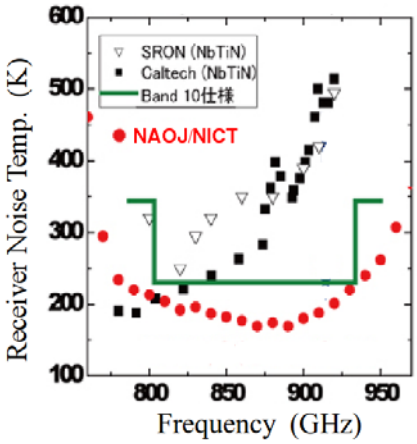

Fig. 3: Performance of Band 10 SIS mixer using a NbTiN thin film.

The mixer for the receiver shown in Fig. 3 uses a Nb/AlOx/Nb SIS junction with a relatively low current density (j_c~8 kA/cm^2). Thus, the frequency band for low-noise operation is limited to be narrow, and the margin for the required frequency band (green line) is barely secured. It is very important for improving the mass-production efficiency to achieve large margin between the specification and actual mixer performance by extending the frequency coverage of the SIS mixer, because such a large margin can absorb a little shift of the frequency coverage of the SIS mixer caused by the size variation of patterns of mixer circuits and consequently increase the production yield of mixer devices. To expand the frequency coverage of the SIS mixer, it is definitely necessary to develop a high-quality SIS junction with both a high current density of j_c = 15 kA/cm^2 or more and an area of 1 μm^2 or less. Instead of conventional AlOx, AlN is a promising candidate for the tunnel barrier of a high-current-density and high-quality SIS junction. Currently, we have been developing a high-quality and high-current-density Nb/AlN/Nb SIS junction in addition to the development of a high-quality NbTiN, to achieve fully in-house manufacturing at the National Astronomical Observatory of Japan.

The author thanks the members of the ALMA receiver development group at the National Astronomical Observatory of Japan for valuable discussions and advice during the SIS mixer development.

1) Y. Uzawa *et al,* "A sensitive ALMA Band 10 SIS receiver engineering model", Supercond. Sci. Technol., 22, 114002, 2009.

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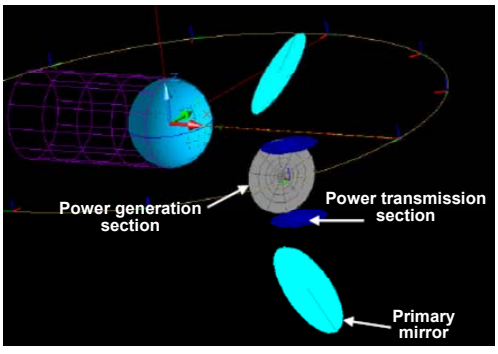
Feature Article: Superconducting Microwave/Optical Devices - Overview of the Solar Power Satellite (SPS) Project

Kozo Hashimoto
Research Institute for Sustainable Humanosphere, Kyoto University

The Solar Power Satellite (SPS) was taken up into one of the Basic Plan for Space Policy of the government in June 2009 as the "H. Space Solar Power Program" A typical SPS is a satellite that is launched into a geostationary orbit to generate electricity with solar cells and transmit a power of approximately one million kW (1 GW) down to Earth via microwaves in the 2.45 GHz or 5.8 GHz frequency band. It is spotlighted as a clean self-supplied power source that can generate electricity for 24 hours without being affected by weather conditions and without emitting carbon dioxide. In the 5.8-GHz model (2004) of JAXA (Japan Aerospace Exploration Agency) shown in Fig. 1, the diameter of the transmission antenna is 1.8 km, the primary mirror is 2.5 km × 3.5 km, the diameter of the power generation section is 1.8 km, and the total weight is 10,000 tons. The diameter of the reception antenna is 2.74 km and the output to the ground system is 1 GW. As the size of the antenna is extremely large, about 90 % of the transmitted power from the geostationary orbit satellite, 36,000 km above the equator, can be received. In order to transport such a huge system into the orbit, a reusable system that can be launched at 1/10th or less of the cost for the ongoing Space Shuttle program is expected. From the aspect of microwaves, a large system is required to be constructed while improving the efficiency to reduce the weight. Coexistence with the existing communication services is also important, and we are currently submitting contribution documents to the ITU (International Telecommunication Union).

Reference model (JAXA 2004 model)

<Principal dimensions>
- Primary mirror : 2.5 km x 3.5 km
  - 100～300 g/m^2 → One side 1000 ton
- Power generation section: φ1.25 km (quadruple of light collection)
  - Use of a wavelength-selective film
- Power transmission section: φ1.8 km
  - Rectenna diameter: 2.74 km
- Total mass weight: 10,000 tons
- Microwave frequency: 5.8 GHz



<Features>
- Secure the heat-dissipating surfaces by separating the power generation section from the power transmission section (structurally independent).
- The reflector mirrors are independent from the power generation and transmission sections and they are to make a formation flight.

Fig.1 JAXA Reference model (© JAXA)

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For specifically describing the transmission system to some extent, a 10-dB taper in power density is applied between the central and the end of the transmitting array in order to focus the beam to the center and reduce the side lobes. In the case of the JAXA model, when the antenna spacing is set to be 0.75 wavelength, the number of elements is about 0.5 billion and the expected power at the center is 6 W per element. Although it is an achievable output with semiconductors, their efficiency is still low. With an inefficient power transmission system, the heat generation will increase, resulting in a difficulty of heat exhaustion, and the system cannot be established as a satellite. If comprised of electronic tubes, the oscillation efficiency is improved, but the power needs to be distributed, thereby the problem of efficiency degradation arises. To accurately position the beam toward the receiving point, a retro-directive system is configured so as to send a pilot signal from the receiving point and direct the beam toward the arrival direction of the beam. To control the beam direction flexibly, the system uses a phased array antenna. As the antenna has a lot of elements, phase shifters for individual elements pose challenges such as loss, phase control, and calibration. The power for controlling the phase shifters cannot be ignored. As the original signal is too large to supply from a single oscillator via a wired system, another challenge is how to phase-synchronize them as an overall system. All of the above are required to be achieved in a lighter and thinner configuration.

For details, please refer to the SPS whitepaper of the URSI (International Union of Radio Science), which was mainly edited by myself *et al*. The URL is as follows: http://ursi-test.intec.ugent.be/?q=node/64

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Feature Article: Superconducting Microwave/Optical Devices -Technological Challenges for Solar Power Satellite Project -

Nobuyuki Kaya, Professor
Department of Computer Science and Systems Engineering,
Graduate School of Engineering, Kobe University

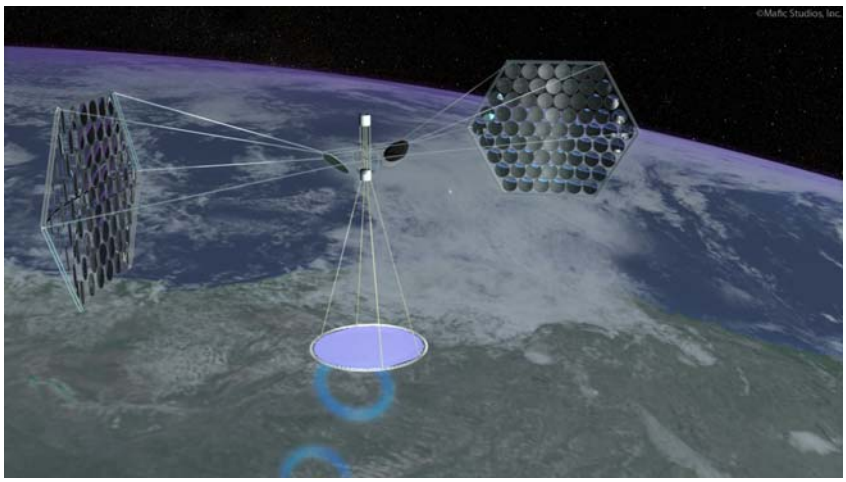

Fig. 1 Solar Power Satellite that collects sunlight by mirrors and transmits electric power to earth via microwaves

This project, which aims at converting electric power generated in space into microwave, transmitting the power to a receiving station (rectenna) on earth, and supplying the power to commercial power grids, is called the "Solar Power Satellite (SPS)." Figure 1 shows the latest structural drawing of the SPS. Unlike a photovoltaic generation system on earth, when generating electricity in space, there is no difference between day and night, and it never rains or snows. It is always possible to supply a constant electric power to earth. When I explain this idea at various lecture sessions, people show interest (?) and say "It is good to hold a dream." "Hold a dream" sounds very good, but I always feel they are thinking "Solar Power Satellite is science fiction in the distant future." Technically, however, the realization is just around the corner. A few years later, it may be possible that an experimental SPS satellite will be launched to carry out an experiment of microwave power transmission from outer space.

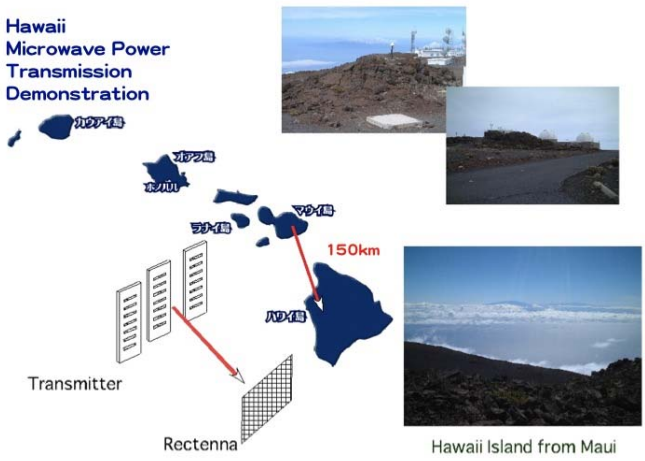

Fig. 2: Radio power-transmission experiment in Hawaii Island

The Solar Power Satellite has many technological challenges: 1) feasibility of microwave power transmission, 2) launching a large number of rockets, 3) construction method for a mega-structure in space as large as a few kilometers, 4) development

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of a photovoltaic cell that does not degrade over a long period, and many more. Listing such challenges might make you think it is not feasible. We are steadily advancing toward the realization by new breakthroughs (e.g., a high-efficiency photovoltaic cell with a generation efficiency of 50 %) in each of the challenges.

Our research challenges are “Wireless Power-transmission Technology and Gigantic Structure Construction in Space.” These days, when I see my friends in the US, they jokingly say, “You have become a TV star!” This is because our microwave power transmission experiment in Hawaii was taken up by the Discovery Channel, a US science television station, and was broadcasted across the country on September 12, 2008. The Japanese version was also broadcast in Japan on December 13.

In Hawaii, there are volcanoes that are at heights of 3,000–4,000 m, such as Haleakala in Maui Island and Mauna Loa in Hawaii Island (Fig. 2). Mt. Mauna Loa is in direct sight from the peak of Mt. Haleakala, which is in the far-off distance of 150 km. When moving upward by 150 km, it is already outer space. We carried out a beam control experiment for wireless power-transmission between space and earth by using an observation rocket S-310-36 launched from Uchinoura, Kagoshima, Japan in January 2006, and we were able to obtain valuable data. (Fig. 3: http://www.isas.ac.jp/ISASnews/No.299/front_line.html)

On the basis of the results, we stepped up to an experiment of a further large-scale antenna in Hawaii. On earth, it is easy to construct antennas of 100–200 m by simply lining up many small antennas. The experiment broadcasted on the Discovery Channel was the first power transmission experiment (Fig. 4). From now, we will add many more small antennas to increase the size of the antenna, with the aim of demonstrating a power transmission antenna for the Solar Power Satellite under the same conditions as SPS. After the successful development, the next step is an experimental satellite in space. This will be the first instance of power transmission from outer space.

.

Fig. 3 Experiment with an observation rocket launched in January 2006

Fig. 4 Power transmission antenna system in Maui Island; this system converts the electricity generated by photovoltaic cells into microwaves and transmits the power from eight small antennas to Mt. Mauna Loa in the far-off distance

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Patent Information

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Planning & Management Division, SRL/ISTEC

Published Unexamined Patents in the 2nd Quarter of Fiscal 2009.

The following are ISTEC's patents published from July through October 2009. For more information, access the homepage of the Patent Office of Japan and visit the Industrial Property Digital Library (IPDL).

Publication No. 2009-164010 "RE - based Oxide Superconducting Wires and their Fabrication Methods":

Superconducting wire used for superconducting application devices are required to have excellent magnetic properties for any angle of applied magnetic field. This invention aims to provide RE-based oxide superconducting tape conductors of excellent applied magnetic field angle dependency in high magnetic fields and their fabrication methods, by introducing homogeneous and tiny pinning centers into thick-film superconductors of excellent grain boundary and crystallinity. The applied magnetic field-angle dependency of critical current density (J_c) can increased substantially while obtaining a superconducting tape conductor that has a high J_c in high magnetic fields by coating and firing an organometallic complex solution with reduced Ba concentration containing metallic elements that comprise an RE-based superconductor and an organometallic complex solution containing Zr, Ce, Sn, and Ti, which have a high affinity to Ba, on an intermediate layer of a composite substrate so as to achieve artificial fine dispersion of Zr-containing oxide particles that are the flux pinning centers.

This RE-based oxide superconducting tape conductor is a $REBa_yCu_3O_z$-based superconductor (RE is Y, Nd, Sm, Gd, or Eu) formed on a substrate via an intermediate buffer layer, where the Ba molar ratio is kept within a range of $y < 2$, and Zr-containing oxide particles of 50 nm or less are dispersed in the superconductor as the flux pinning centers. The composition of RE is $RE = A_{1-x}B_x$, where A and B are composed of one or more different elements from among Y, Nd, Sm, Gd, and Eu; the Ba molar ratio is kept within a range of $y < 2$, and Zr-containing oxide particles of 50 nm or less are dispersed in the superconductor as the flux pinning centers. It could also be an RE-based oxide superconducting tape conductor in which RE has a composition of $RE = Y_{1-x}Sm_x$, and the molar ratio of Ba is kept within a range of $y < 2$ and is characterized by the dispersion of Sm-containing oxide particles and Zr-containing oxide particles of 50 nm or less as the flux pinning centers in the aforementioned superconductor.

For the RE-based oxide superconducting tape conductors and its fabrication methods, it is desirable that the Ba molar ratio is kept within a range of $1.3 < y < 1.8$. By reducing the Ba molar ratio to less than its standard molar ratio, the segregation of Ba, deposition of Ba-based impurities, and appearance of cracks are inhibited, while improving the electrical affinity between crystal grains, thereby resulting in a higher J_c. Further, by reducing the Ba molar ratio, $Y_2Cu_2O_5$ and CuO, which are the flux pinning centers, are formed and the magnetic field properties are improved. The size of the Zr-, Ce-, Sn-, or Ti-containing oxide particles, which are artificially introduced and dispersed in the superconductor as the flux pinning centers, is supposed to be 50 nm or less; however, it is particularly desirable that it be Zr-containing oxide particles of 5 -30 nm. A desirable additive amount of Zr, which is artificially introduced to form the flux pinning centers, is 0.5 -10 molar% in metallic concentration. If the additive amount of Zr is less than 0.5 molar%, then a sufficient pinning force cannot be obtained as the density

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of the oxide particles is insufficient, whereas if the amount exceeds 10 molar%, then the deposits become coarser and the crystalline properties are deteriorated. Particularly, a range of 0.5 - 5 molar% in metallic concentration is desirable.

According to this invention, a high J_c that is comparable to an Nb-Ti alloy superconductor can be obtained at 77 K/1T by the artificial fine dispersion of flux pinning centers (Zr-containing oxides such as $BaZrO_3$ and ZrO_2) in a RE-based superconductor with reduced Ba concentration, while also improving the J_c - B - θ property to obtain isotropic J_c properties, because fluxes can be pinned effectively toward any direction of the magnetic field. Further, the J_c in high magnetic fields and the anisotropy of J_c against the angle of the applied magnetic field are substantially improved in RE-based oxide superconducting tape conductors, which are suitable for a non-vacuum, low-cost process, i.e., the TFA-MOD method; therefore, this invention can be applied to superconducting devices such as superconducting magnets, superconducting transformers, and superconducting power storage facilities.

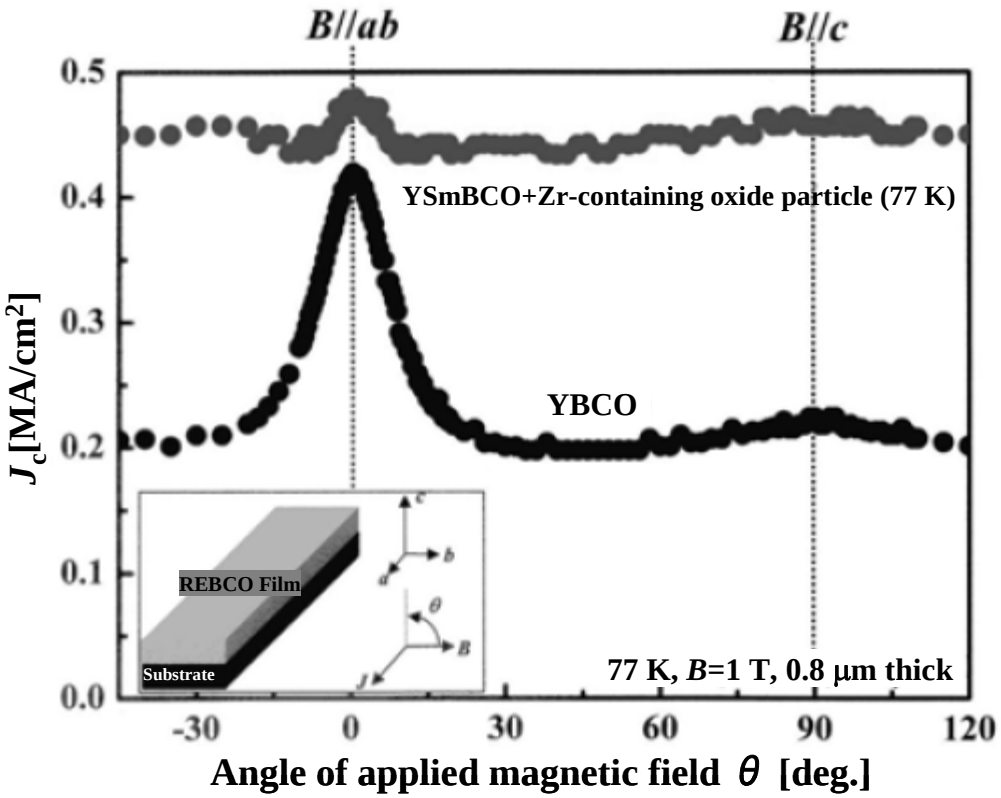

Fig. Magnetic field applied-angle dependency of the superconductor fabricated based on the embodiment and comparative examples of this invention

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Standardization Activities

Topics in December

- IEC/TC90 Superconductivity Committee held “The 3rd Panel Discussion regarding Superconducting Electronics” in Tsukuba -

Yasuzo Tanaka, Director
Standardization Affairs Division, ISTEC

On November 4, 2009, IEC/TC90 Superconductivity Committee (International Superconductivity Technology Center: ISTEC) held the 3rd Panel Discussion regarding Superconducting Electronics in meeting room No. 201A at the Tsukuba International Congress Center (Epochal Tsukuba) in Tsukuba as part of the standardization activities concerning superconducting electronics. With 11 participants from four countries, the discussion was successfully completed.

The discussion was chaired by Mr. Masataka Ohkubo (National Institute of Advanced Industrial Science and Technology: AIST).

At the discussion, Mr. Ohkubo reviewed the past panel discussions regarding superconducting electronics, and Mr. Yasuzo Tanaka (Secretary of JNC, IEC/TC90 Superconductivity Committee, IEC/TC90 Secretariat) proposed “Superconducting Sensor” as the theme for the international standardization in the future superconducting electronics field. After that, the following five panelists presented technical information on superconducting sensors and proposed items that should be standardized in the field of superconducting electronics.

1. Opening:
1) M. Ohkubo, AIST, Review past panel discussions
2) YasuzoTanaka, ISTEC, International standardization scheme of superconducting sensors

2. Panelist: 10-minute presentation using PPT, and 5-minute free discussion
1) Saburo Tanaka, TUT, SQUID magnetometer
2) K. Mitsuda, JAXA, Microcalorimeter for photon detection
3) Z. Wang, NICT, Superconducting single photon detector using niobium compound
4) R. Cristiano, CNR-ICIB, Superconducting nano-wire detector of photon and molecules
5) M. Ohkubo, AIST, Superconducting molecule detectors

3. Free discussion

4. Closing: M. Ohkubo

On the basis of the results from previous two panel discussions and the technological trends of superconducting sensors in recent years, the following were the important points obtained from the 3rd Panel Discussion, concerning the international standardization of superconducting electronics.

1) Interdisciplinary exchange of technical information was promoted in a wide range of superconducting active element fields from SQUID to THz heterodyne detector and to particle detector.

2) In any of these fields, superconductivity plays a considerable role; therefore, it is appropriate to promote superconducting sensors or superconducting detectors as a new target for international standards.

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3) As an image of superconducting sensor standard, the application range, citation standard, related terminology/definition, classification, and general requirements etc., which comply with the current general principle of the IEC standard, are appropriate for the structure of the standard.

4) It was recognized that we should carry out continuous standardization activities toward building an international consensus on related terminology/definition and classification etc. for superconducting sensors through such discussions and related researches in the future.

A scene from the 3rd Panel Discussion regarding Superconducting Electronics

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Standardization Activities

Topics in December

- IEC/TC90 and VAMAS/TWA16 held a regular joint conference at NIMS in Tsukuba -

Yasuzo Tanaka, Director
Standardization Affairs Division, ISTEC

On November 5, 2009, IEC/TC90 and VAMAS/TWA16 held a regular joint conference in meeting room No. 2 in the Sengen Site Central Building of National Institute for Materials Science (NIMS) in Tsukuba. Active discussions were held by 16 participants from five countries.

A scene from the IEC/TC90-VAMOS/TWA16 regular joint conference

Chaired by Mr. Hitoshi Kitaguchi (NIMS) of VAMAS/TWA16 presidency holder, the conference was proceeded as follows:

1) Opening and Brief report on TWA16 activities by H. Kitaguchi (NIMS)
2) IEC/TC90 activities by Y. Tanaka (ISTEC)
3) Introduction of IEC/TC90 activities on Current Leads by Prof. T. Mito (NIFS)
4) Activities in Germany by W. Goldacker (FK) and M. Thoener (EAS)
5) Activities in USA by H. Weijers (NHMFL)
6) Activities in China by G. Zhang (IEE/CAS)
7) Activities on AC loss of YBCO coated conductors by E. Collings (OSU)
8) Activities on Surface resistance by S. Y. Lee (Konkuk Univ) and S. Kosaka (AIST)
9) Activities on NDE of I_c by H/ Yamasaki (AIST)
10) Activities on Irreversibility field measurements by T/ Matsushita (KIT)
11) Topics on Flux pinning by J. Sosnowski (IEL)
12) Activities on Mechanical properties by K. Osamura (RIAS)

At this joint conference of IEC/TC90 and VAMAS/TWA16, the following topics were brought up:

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1) Introductions and progress reports were delivered regarding current lead and its test method, surface impedance test method, test method for power dependency of surface resistance, and nondestructive test method for critical current density, which are the standards currently under deliberation.
2) As a result of the pre-standardization at VAMAS, room-temperature tensile test method for Bi-based wires was proposed as a new task of IEC.
3) Efforts have been initiated to dispel the “uncertainty” in the pre-standardization at VAMAS.
4) Various test results from applying new wires such as coated conductor and MgB_2, which were outstanding issues from the previous conference, have begun to be reported.
5) In the future, the pre-standardization is expected to be achieved by systematically accumulating the data while continuously carrying out round-robin tests (RRT) of bending property, AC loss, irreversible magnetic field, pinning effect, and their uncertainties.

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