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Superconductivity

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Feature Articles : ISS2005 Topics
- The 18th International Symposium on Superconductivity (ISS 2005) -

The International Superconductivity Technology Center (ISTEC) held the 18th International Symposium on Superconductivity (ISS 2005) at the Tsukuba International Congress Center (EPOCHAL TSUKUBA) over a three-day period from October 24 (Monday) to 26 (Wednesday), 2005. The ISS is held each year, and this year was its 18th anniversary. The purpose of the ISS is to promote the development and commercialization of superconductive technology, to promote the use of the technology among the general public, and also to familiarize them with it. These goals are accomplished through domestic and overseas research into superconductivity, the presentation of results obtained from technological development, and international exchange. A total of 595 participants, including 109 from 16 countries, attended the symposium, making it quite an international affair. There were a total of 493 presentations, consisting of 132 oral presentations and 361 poster presentations, including 74 invited speakers, almost the same total as last year. Papers from the symposium will be collated and published as a special volume of Physica C (Elsevier B.V.), an academic journal. In addition, 10 companies exhibited superconducting materials, products, and technology.

An opening address was delivered by ISTEC Vice President S. Tanaka on the first day, and a congratulatory address from Minister S. Nakagawa of the Ministry of Economy, Trade and Industry was delivered on his behalf by T. Takahashi, Director-General of the Kanto Bureau of Economy, Trade and Industry. Subsequently, two special plenary lectures and six plenary lectures were delivered, with the program being chaired by Y. Okabe (The University of Tokyo), and R. A. Hawsey (Oak Ridge National Laboratory). The special plenary lectures were about the "Sustainable Future of Energy and Superconductivity Applications," presented by E. Masada (Tokyo University of Science), and "Electric Power Applications of High Temperature Superconductors," presented by G. J. Yurek (American Superconductor Corporation). Meanwhile, the plenary lectures focused on the "Search for New Superconductors and Related Materials," presented by E. Takayama-Muromachi (National Institute for Materials Science), the "Processing and Properties of Single Grain (RE)-Ba-Cu-O Bulk Superconductors," presented by D. A. Cardwell (University of Cambridge), "Power Applications of Bulk Superconductors," presented by H. Ohsaki (The University of Tokyo), the "Development of the Superconducting Motor for Ship's Propulsion – Consideration of Superconducting Materials Utilization - ," presented by Y. Nakagawa (Ishikawajima-Harima Heavy Industries Co., Ltd.), "Superconductive Electronics with HTS Materials in Europe," presented by H. Rogalla (University of Twente), and "Biological Immunoassays with HTS SQUID," presented by K. Enpuku (Kyushu University). A banquet was also held in the evening to encourage active exchanges among the participants.

Photo 1 Prof. Tanaka, Vice President of ISTEC, delivering the opening address

On the second and third days, oral sessions were given and two poster sessions held under the five categories of physics and chemistry and vortex physics, bulks and characterization, wires, tapes and characterization, films, junctions and electronic devices, and a new category added this time, large scale system applications. The participants engaged in earnest discussions during these presentations and sessions.

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In the physics and chemistry session, a mini-symposium entitled "Towards Higher Tc" was held, which offered opportunities for dialogue on the latest topics, such as new superconducting materials and the elucidation of the superconducting mechanism of high-Tc copper oxide. In the bulks and characterization session, the latest topics, including manufacturing research on increasing size and improving critical current and assessment technology for commercialization, and the latest results were reported and discussed. In the wires, tapes and characterization session, the latest technological development results concerning Y high-temperature superconducting wires/tapes in Japan, the U.S., and Europe, the current density of tape wire material, the assessment method of characterization for such things as current loss, and applications in the field of electrical equipment were reported and lively discussions held. In the films, junctions and electronic devices session, the topics of SQUID for Y high-temperature superconducting and filter development, as well as the development results for AD converters for Nb low-temperature superconducting, routers, high-integration devices such as SFQ processors, and super-fast energy-saving servers were reported. Furthermore, in the large scale system applications session, development progress, including that for industrial applications such as superconducting magnets and motors, generators/transformers, and maglev bearings, and verification testing for electrical system applications for such things as cables, SMES, and current-limiting devices were reported.

At the closing of ISS 2005 in the afternoon of the third day, Y. Koike (Tohoku University) summarized the presentations from the physics and chemistry sessions, K. Hirata (National Institute for Materials Science) the presentations from the vortex physics session, M. Murakami (Shibaura Institute of Technology) those from the bulks and characterization session, Hawsey those from the wires, tapes and characterization session, Rogalla those from the films, junctions and electronic devices session, and T. Hamajima (Tohoku University) those from the large scale system applications session. Finally, S. Tanaka (ISTEC/SRL), who served as chairperson of the organizing committee for ISS2005, delivered the closing address, stating his eagerness to meet again at ISS2006, which is scheduled to be held in Nagoya for the three days between October 30 and November 1, 2006. Thus wrapped up another successful International Symposium on Superconductivity.

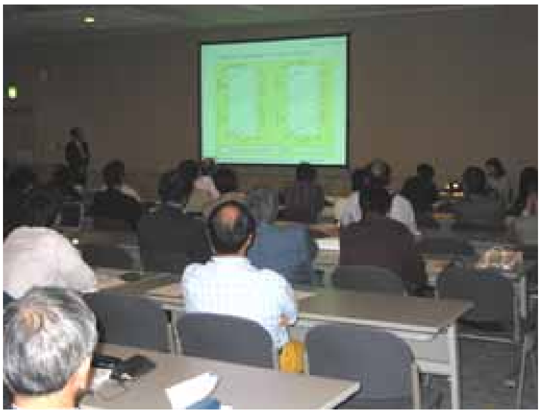

Photo 2 Oral session

Photo 3 Poster session

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

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Feature Articles : ISS2005 Topics
- Physics and Chemistry -

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National Institute of Advanced Industrial Science and Technology

Noriko Chikumoto
Division of Material Science & Physics
SRL/ISTEC

The physics and chemistry session was divided into the categories of physics and chemistry (PC) and vortex physics (VP). Each year, a symposium is planned at the PC session, and on the second day this year, a mini-symposium was held on the topic of "Towards Higher-T_c." Regarding the determinants of T_c, Y. Uemura (Columbia University) had been advocating a scale law in which T_c is proportional to superfluid density, but this time he pointed out that the resonance mode observed in inelastic neutron scattering corresponds to the roton mode in a superfluid of liquid helium, and that this could possibly play a substantial role in pair formation for high-temperature superconductivity. Meanwhile, C. C. Homes (Brookhaven National Laboratory) asserted that making T_c proportional to electrical conductivity multiplied by T_c, instead of proportional to superfluid density, made it easier to quantitatively explain experiment results, and he also showed that this law applies even to conventional superconductors. Regarding heavily doped La214, S. Wakimoto (Japan Atomic Energy Agency) concluded from the results of neutron scattering that magnetic interaction is essential to pair formation in high-temperature superconductors, while T. Adachi (Tohoku University) pointed out the possibility that phase separation is occurring in heavily doped La214, based on the results of precise magnetic susceptibility measurements.

Regarding the relationship between *n*, the number of copper-oxygen (CuO_2) planes that exists within the unit cell of a copper-oxide superconductor, and T_c, A. Iyo (National Institute of Advanced Industrial Science and Technology) showed that T_c will be at its maximum value when $n = 3$, regardless of the type of material, and for $n > 4$, it will be a constant value. Regarding this, Y. Kitaoka (Osaka University) pointed out that based on NMR measurements, the inner CuO_2 plane in an $n > 4$ material has a marked tendency to be under- doped, which brings about magnetic ordering. Meanwhile, Y. Chen (Stanford University) asserted that, based on results from angle-resolved photoelectron spectroscopy (ARPES), both the outer and inner CuO_2 planes in a nominally zero-doped fluorine copper oxide superconductor are optimally doped. M. Mori (Tohoku University) proposed a theoretical explanation which accounts for the apparent contradiction. As for the differences in T_c according to the material of the copper oxide superconductor, T. P. Devereaux (University of Waterloo) pointed out that they were due to the different electron phonon coupling which is sensitve to the crystal symmetry. In addition, T. Yoshida (The University of Tokyo) reported that, based on ARPES results, the quasi-particle structure of under-doped regions differed between La and Y on the one hand, and Bi on the other. Based on the results of controlling the a-axis length with a substrate on La214 superconductor film, H. Sato (NTT Basic Research Laboratories) found that T_c climbed to 44K, far exceeding bulk T_c (38K), in thin film with the shortest a-axis length. Furthermore, I. Bozovic (Brookhaven National Laboratory) created an La superconductor/half-strength magnetic insulator/superconductor junction structure and showed that a long-range proximity effect arose with an insulator in between.

Finally, there were five presentations on advances in n superconductors. M. Kato (Tohoku University) reported that 8K superconducting results from intercalating lithium into complete halogen ($Sr_2CuO_2X_2$, X=Br, I).

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P. Dai (Oak Ridge National Laboratory) showed that there is a quantum critical point near x = 0.12 in this type, based on the results of the neutron scattering of $(Pr, La, Ce)_2CuO_4$. In addition, T. Sato (Tohoku University) showed that, based on ARPES results, the electronic state of this type is greatly affected by half-strength magnetic fluctuation and the symmetry of the superconducting gap is not a simple *d*-wave, while T. Tohyama (Tohoku University) showed that these experimental results could be consistently explained by the t-J model. Furthermore, T. Sasagawa (The University of Tokyo) made it clear that the measurement results of the uniaxial pressure effect on an n-type superconductor differed from the behavior of the p type.

There were reports on a broad range of vortex physics-related subjects, including micro and macro observations of vortices, the behavior of vortices, and THz radiation using Josephson vortices. P. Leiderer (University of Konstanz) reported on the magneto-optical observation of flux avalanche at a resolution of 100 ps. Based on experimental results for SANS, D. M. Paul (University of Warwick) showed that vortex lattice structures of V_3Si and non-magnetic nickel borocarbides have a phase transition from a square to a triangular lattice with temperature and magnetic fields. The phase transformation in V_3Si was explained in terms of gap anisotropy. T. Nishizaki (Tohoku University) performed a detailed study on *ab* in-plane anisotropy of YBCO single crystal by means of vector current analysis, and discovered that in the Bragg-glass phase, flux lines move only in the *b* axis direction, regardless of the current's direction. Regarding THz radiation, S. Savel'ev (The Institute of Physical and Chemical Research (RIKEN)) proposed a variety of control methods and showed their calculation results. THz radiation is expected to be a technology that will open up new application fields for high-temperature superconductors. We hope the experimental verification will move forward in the future.

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Feature Articles : ISS2005 Topics
- Bulks and Characterization -

At the ISS2005 session on bulks, there were 15 oral presentations and 50 poster presentations in which the latest research results on material development and applications were reported. There were many researchers who had attended the 5th International Workshop on Processing and Applications of Superconducting (RE) BCO Large Grain Materials (5th PASREG) held at the Tokyo University of Marine Science and Technology from October 21 to 23, 2005, so there was an even deeper level of discussion and more friendly contact than in normal years. An introduction of the main topics follows.

Regarding materials development, there have been many advances, including enlargement of bulk size, fabrication processes, and new pinning centers. On the enlargement of bulk size, there were three reports from SRL about very large Gd bulk superconductors with a diameter of 140 mm. This was based on results obtained in superconductor manufacturing tests conducted in space, and the bulk samples were fabricated using a precursor that includes the Gd_2BaO_4 phase. The formation process, crack suppression, and trapped magnetic field characteristics of bulk superconductors were discussed during the session. Since an increase in diameter of bulk sample produces a high magnetic field, even at a distance from the bulk surface, a variety of applications are anticipated. The group from University of Cambridge presented a number of extremely interesting reports on the bulk fabrication process, such as the characteristics of bulks fabricated by the infiltration process, and the development of novel seed crystals. N. Hari Babu et al. discovered that Mg doping to Nd123 seed crystals improves the melting decomposition temperature, and they succeeded in fabricating large Sm and Nd bulk samples by the cold-seeding process. About the new pinning center to replace the RE211 phase, YBa_2 (Cu, M) O_6 (M = W, Nb, Zr, Sn, Bi, etc.) as well as Ir, Ru, $BaCeO_3$, and SnO_2 are being studied.

Regarding bulk applications, M. Kitano (Kitano Seiki Co. Ltd.) introduced the development of their small, high-torque bulk high-temperature superconducting motor, and reported on increased output by adopting twin rotors and the field magnetization method using a multilayered spiral coil. H. Fujishiro, et al. (Iwate University) made a presentation highly worthy of attention in which they announced their success in the highest magnetic field trapping (5.20 T) in the world by means of pulse field magnetization. This was achieved by applying the fundamental research accumulated up till now by their group, including the analysis of thermal behavior when applying pulses and waste heat due to metal rings. Notably, in the system applications session, there were reports on bulk applications, including the results of NEDO's flywheel project and superconducting magnets for NMR.

(Shinya Nariki, Bulk Superconductor Laboratory, Division of Material Science & Physics, SRL/ISTEC)

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Feature Articles : ISS2005 Topics
- Wires, Tapes and Characterization -

The Wires, Tapes, and Characterization session consisted of 128 reports, 100 of which were poster presentations, and 28 oral presentations. The breakdown for the oral presentations was four each on MgB_2 and Bi wires, with the remaining 20 (70% of the total) on Y wires. The following represents the major content of each part of the session.

Particularly notable among the reports on MgB_2 was the improvement in characteristics achieved by H. Kumakura (National Institute for Materials Science) (WT-1) through materials development using an ex-situ process. It had thus far been asserted that characteristics would not improve over an in-situ process when using an ex-situ process, but this time Kumakura succeeded in obtaining higher characteristics than an in-situ process by taking out the MgB_2 that was fabricated as wires, and then grinding, filling, and drawing it again. In addition, Kumakura also reported the fabrication of a coil in joint research with Hitachi, and the confirmation of its persistent current state.

In a report on Bi superconducting wires, J. Bock (Nexans SuperConductors GmbH) (WT-5) announced that they had fabricated raw material using a new technique of the semi-molten process for 2212 wires, promoted homogenization, and succeeded in improving characteristics. He also introduced their approach to current limiters and transformers as applications. Regarding the development of 2223 wire, M. Kikuchi (Sumitomo Electric Industries, Ltd.) (WT-6) reported their results on improved characteristics through a firing process in a high-pressure oxygen atmosphere. Kikuchi announced that the characteristics of long wires are steadily improving, and that they had at the current time reached 166A.

As for the review of the various areas relating to Y wires, in the Special Plenary Lecture, G. J. Yurek (American Superconductor Corporation) (SPL-2) gave a report centering on the company's results and strategies. Particularly in the area of next-generation Y wires, Yurek stated that their so-called 344 tape, which is a three-layer 4.4 mm wide tape inserted between copper on the top and bottom, symbolized future developments, and then announced their plan aiming for an annual production of 300 km in 2007. Regarding trends in the United States, R. A. Hawsey (Oak Ridge National Laboratory) (WT-9) provided an introduction that included results from other laboratories as well. Hawsey introduced the achievement of 107A at 207 m as a result of a length increase from IGC-SuperPower, success in improving characteristics in magnetic fields and low cost processes, and success in lowering AC loss by enabling multiple filaments by fluting. And in addition to the Department of Energy's (DOE) target values of a 100 m x 300 A/cm width by the end of FY2006, and 1000 m x 1000 A by the end of FY2010, Hawsey introduced the newly proposed target value of 200A (3T, H//c, 65K) on 4 mm-wide wires by FY2008. Meanwhile, Y. Shiohara (SRL/ISTEC) (WT-10) introduced development results in Japan. Within the national project on Research and Development on Basic Technologies Required for Superconductivity Applications, development is under way toward the intermediate goal of a 200 m x 200 A/cm width by the end of FY2005, followed by the achievement of a 500 m x 300 A/cm width by the end of FY2007. Starting with the results for IBAD-PLD wires that achieved the world's highest IcxL, the results for improved characteristics and extended length for various types of wire in the MOD, MOCVD, and other methods were introduced, along with the results in successfully generating a magnetic field in a number of coil tests, and the good results that were obtained in, for example, current tests during conductor experiments for cables. In addition, research on machinablity with cables, transformers, rotating machines, and so on in mind, has commenced, and a proposal was introduced for cutting-edge research on various equipment into FY2006. From Korea, S. S. Oh (Korea Electrotechnology Research Institute) introduced the results and plans of DAPAS, a superconductivity development organization in that country. DAPAS members include KERI, KIMM, SNU, and KISWIRE, and

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they are respectively in charge of developing the PVD, MOD, IBAD, and RABiTS processes. While they are behind Japan and the U.S. in terms of length and characteristics, they are working toward the target of 300 m x 125 A/cm width by the end of FY2007. From Europe, W. Prusseit (THEVA Dunnschichttechnik GmbH) gave a presentation, but it was more of an introduction to the company's results and strategies than of the situation in Europe itself. They are developing wire material using a technique that forms a Dy superconducting layer by co-vapor deposition onto an ISD intermediate layer of MgO material, and they are achieving an average Ic of 330 A/cm width with a 9 m wire. In aiming toward application, Prusseit introduced the unique idea of fabricating current leads and implementing 50µW/A, as well as making notches for twisted wire.

The following presents individual results by subject. First off, regarding increased length, Y. Yamada (SRL/ISTEC) (WT-14) gave a report on the development of wires with the world's highest IcL layer. They positioned a CeO_2 cap layer on an IBAD-GZO and then attempted to increase speed by multi-plume and multi-turn, particularly for the PLD method, in the technique that forms a YBCO layer on it by the PLD method, as well as to improve the characteristics of long wire by temperature control (increasing the set temperature) for increased film thickness. They are now succeeding in fabricating wires that indicate 245 A at 213 m. Following this is IGC's 207 m x 107 A. According to J. Reeves (SuperPower, Inc.) (WT-21), they are obtaining wires by means of a method that fabricates a superconducting layer by MOCVD using a IBAD-MgO substrate, and the improvement of characteristic distribution in the longer direction that exists is being set as a future issue. The third results report was from Y. Iijima (Fujikura Ltd.) (WT-13). According to Iijima, they are succeeding in fabricating wire with a characteristic of 88 A and maximum length of 217 m. In the top 10 reported at the symposium, it become clear that Japan leads the world, accounting for over half of the results comprised of Sumitomo Electric Industries Ho wire (WT-16), Chubu Electric Power's MOCVD wire (WT-20), and Showa Electric Wire & Cable and SRL's MOD wire (WT-17&19), etc.

Next, regarding the development of high Ic, V. Matias (WT-15) of LANL reported that they had realized a 1400 A/cm wide high-Ic wire by building up an extremely thin layer of YBCO film with extremely high Jc on a multilayer structure (YBCO/CeO_2/YBCO /CeO_2/…). After this is, of course, the achievement of thick film with high Jc, the maintenance of a high Jc of 2M A/cm^2 up to a thickness of 4 µm, and the obtaining of an 800 A/cm width in wires by an ex-situ process in the United States. In Europe, THEVA reported (WT-12) achieving a 486 A/cm width, and in Japan, SRL Nagoya (WT-14) is reaching a 480 A/cm width with Gd, while SRL Tokyo (WT-17) is reaching a 470 A/cm width by developing a crack suppression method, which was an issue with thick film in TFA-MOD.

Lately, the development of artificial pinning control technology aimed at improving characteristics in magnetic fields has been blossoming. First, R. A. Hawsey reported ORNL's results in improving Jc-B characteristics by a technique that disperses BZO particles into YBCO film. The same results were also achieved in Japan, and Yamada of ISTEC obtained an Ic of 40 A within a 3T magnetic field by introducing BZO into YBCO film through a process that disperses YSZ to a target when fabricating YBCO film by means of PLD. This was characterized by the BZO particles being arranged in the c axis direction, and although the mechanism has not been made clear, this arrangement delivers a marked improvement in c//B characteristics. In addition, K. Matsumoto (Kyoto University) (WT-22) is confirming the improvement in Jc-B characteristics by placing nano dots (Y_2O_3) on the substrate and then deliberately introducing defects by forming a film on it. As for approaches that use an RE other than Y, Y. Yoshida (Nagoya University) achieved a highly oriented SmBCO film by low-temperature vapor deposition for which characteristics can be expected after forming layers at high temperature, and they are succeeding in fabricating high Jc-B film with excellent characteristics in magnetic fields and a particularly low anisotropy.

Finally, for approaches aimed at an extremely low cost structure, we can also see advances in attempts to manufacture all layers using MOD. According to T. Hasegawa (Showa Electric Wire & Cable Co., Ltd.)

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(WT-19), a superconducting layer in which a $Ce_2Zr_2O_7$ intermediate layer is formed by MOD on a Ni-W oriented metal substrate and a cap layer of CeO_2, is formed by PLD, attained 0.75M A/cm^2 in a structure fabricated using TFA-MOD. In the United States, M. P. Paranthaman (Oak Ridge National Laboratory) (WT-18) reported that they are attempting to improve film thickness and fabrication conditions jointly with AMSC by using a method that forms LZO and CeO_2 by MOD on a Ni-W oriented metal substrate, just like Showa Electric Wire & Cable does, and then forms YBCO film by TFA-MOD on the top layer. Furthermore, they have succeeded in improving orientation by positioning an extremely thin layer of Y_2O_3 at the boundary between the metal substrate and LZO, and they are achieving widths of Jc = 2.5 M A/cm^2 and Ic = 200 A/cm.

That wrapped up the subject matter presented on the development of processes for Y wires, but in closing I would like to note that both Shiohara (Japan) and Hawsey (the United States) stressed that preparations are underway for the development of equipment, along with the advance in long wire process development, and the time to take the next step has arrived, and the facts indicates that sound progress is being made in this field.

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

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Feature Articles : ISS2005 Topics
- Films, Junctions and Electronic Devices -

In the films, junctions and electronic devices session, presentations were given in a wide range of fields, from SQUIDs and superconducting filters that are already reaching the practical application level, to the development of low-temperature SFQ circuits and an oxide SFQ circuit, and the search for (Cu,C)BaCaCuO materials. In the keynote speech, H. Rogalla (University of Twente) introduced the state of high-temperature superconducting electronics in Europe. Voltage standards and medical SQUIDs are contributing to the practical use of superconducting devices in Europe, but the devices are being mainly pursued as fundamental research. They are attempting to observe the several intrinsic junction characteristics in the mesa structures of Bi oxide film, and also form junctions by building up Au/Nb film from a different direction than the in-plane direction, with Y-123 oxide film as the lower electrode. They are also proposing memory that uses ferromagnetic dots for writing and superconducting junctions for reading.

Several examples of practical use through the application of SQUIDs were introduced. At Kyushu University and other institutes, immunologic tests with SQUIDs as detectors were performed using Fe_2O_3 for antigen-antibody reaction markers. Detection by SQUIDs does not require the cleaning and elimination of unreacted markers and offers other benefits compared with conventional optical methods, such as high sensitivity and shorter measurement times. One hundred times (0.03 pg) the sensitivity of the optical method was achieved by optimizing Fe_2O_3 particle size to a diameter of 25 to 30 nm. The development status of a magnetocardiograph was introduced by Hitachi. Of particular note was the current distribution map corresponding to QRS waves that was shown. The map was produced by processing data read by a 64-channel magnetocardiograph. Sumitomo Electric Hightechs showed that 0.3-mm diameter SUS304 in meat could be detected using SQUIDS in food inspections. When an attempt is made to detect a high-speed signal with a SQUID, the detection frequency will be decided by the signal feedback time of the FLL circuit since the SQUID itself will be high speed. At PTB, signal detection up to 20 MHz was enabled by building a data processing system onto an 13 x 4.3cm^2 FLL board.

In the area of digital applications, Chalmers University of Technology is developing a DSP for improving the communications efficiency of radio base stations and satellites. They are developing a 5x5 multiplier and 4x15 shift register memory chip that operates at 33 GHz, and will package them in a multichip module (MCM). In addition, verification of 40 GHz operations for a 4x4 switch scheduler (SRL) and 30 GHz operation of a 4-bit integer multiplier (Nagoya University) were introduced. The degree of integration for these low-temperature SFQ circuits was on the level of several thousand. When the number of junctions reaches several tens of thousands, the effect that the magnetic field produced by bias current has on SFQ circuit operation becomes more serious. The magnetic field generated by bias current was observed using a SQUID microscope (SRL), and evaluated using SQUID characteristics built into a chip (NICT).

IBM tried out a photon detector that used the S-N transition of NbN film as a sensor for IC defect tests. Compared to avalanche photodiodes, the conventional element that is used, shorter jitter (18 ps) and lower background (0.01 cps) characteristics were achieved although the quantum efficiency was the same. As for materials and film, NTT is achieving superconductive properties of T_{con}=105K, T_{czero}=55K(n=4) using $(CuC)Ba_2Ca_{n-1}Cu_nO_x$ film. Meanwhile NIMS and others are getting interesting results showing that a diamond structure CVD film doped with boron will have Tc = 5.9K superconductivity.

(Yoshinobu Tarutani, Division of Electronic Devices, SRL/ISTEC)

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Feature Articles : ISS2005 Topics
- Large Scale System Applications -

Hiroyuki Ohsaki, Professor
Graduate School of Frontier Sciences
The University of Tokyo

Atsushi Ishiyama, Professor
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Waseda University

During the large-scale system applications session, an oral session and a poster session were respectively held in the morning and evening of the second day, while other oral sessions were held on the afternoon of the third day. The following is mainly a report of the content of the oral sessions.

In the second day's oral session, M. McCarthy (American Superconductor Corporation) reported on the development of a shielded cold dielectric high-temperature superconducting cable. McCarthy showed that the cable delivered low loss, a low leakage field, and low impedance, making possible efficient use of electric power networks with good controllability. S. Mukoyama (The Furukawa Electric Co., Ltd.) reported on the development of a superconducting cable that employs YBCO wires. The use of YBCO wires is expected to contribute to dramatic cost cuts for cables. A prototype 1-m two-layer cable using 32 YBCO tape wires was actually manufactured, and it delivered a critical current of 1459 A and AC loss of about 0.3 W/m/kA. Next, H. Xi (Innopower Superconductor Cable Co., Ltd.) reported on the operating status of the 30-m long 35 kV-2 kA superconducting cable in China. Operation commenced on April 19, 2004, and by July 31, 2005 it had supplied 160 million kWh of electricity. K. Kajikawa (Kyushu University) reported on their proposal for a three-phase superconducting cable with a structure that arranges tape wires radially, and the N-period in the circumferential direction in the order of the three phases (U, V, and W), followed by the analysis results for its AC loss characteristics.

In between intermissions, K.M. Amm (GE Global Research Center) reported on the development status of power generators and MRI, among the various superconducting equipment developments at GE. Their 100 MVA superconducting generator has a stator of the same structure as the conventional type, and a rotor with a high-temperature superconducting field winding, but with a room-temperature iron core. The results of a cost study were also introduced. Y. Iwasa (MIT) introduced the currently ongoing NMR/MRI magnet project at MIT's Francis Bitter Magnet Laboratory. Design study results were reported for a 1 GHz LTS/HTS NMR magnet (20T super class magnet), a magnet employing YBCO bulk rings, and a magnet employing MgB_2 wire. H. Hata (Railway Technical Research Institute) reported on the development status of railway onboard transformers that aim to reduce size and weight and increase efficiency. A rating of 3.5 MVA and short-time rating of 4 MVA have been achieved, and a 10-minute 42 kV withstand voltage test and 150 kV impulse voltage test have also been performed without a hitch. AC loss was 6.2 kW (at 3.5 MVA) and efficiency 96% to 97% at 66K operation. N. Koshizuka (SRL/ISTEC) reported their development and test results for a flywheel energy storage system using superconducting magnetic bearing. The levitation force density of the superconducting bearing was 11 N/cm^2 at 77K, and 17 N/cm^2 at 67K, and energy storage of 5.0 kWh was recorded at 11,250 rpm.

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Four presentations were given from Japan during the large-scale system applications oral session on the final day. First, N. Hirano (Chubu Electric Power Co., Inc.) introduced Japan's SMES Project. In Phase III, which kicked off in 2004, following Phase I (1991 to 98) and Phase II (1999 to 2003), they plan on manufacturing a prototype Bi-2212 coil and evaluating its characteristics, as well as developing a 20 MJ coil and conducting actual field tests on it to advance performance and lower costs. A. Kawagoe (Kagoshima University) reported their results on evaluations of contact resistance between strands based on comparisons of coupling loss between strands of a Bi-2212 Rutherford cable that they envisioned for SMES by tests and the 2D finite element method. A. Ishiyama (Waseda University) introduced their results for characteristic deterioration tests on YBCO wire when carrying an overcurrent pulse, which they envisioned in such applications as transmission cables. T. Tosaka (Toshiba Corporation) reported on their design results for two six-pole magnets for neutron convergence that wound YBCO wire edgewise and flat, respectively, and he showed that the former provides a large field gradient. Finally, in the closing session, T. Hamajima (Tohoku University), emphasized the need for development of superconducting power equipment while summarizing the presentations in the large-scale system applications session.

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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology
- Advances in Superconducting Microwave/Terahertz Wave Device Technology -

Shigetoshi Ohshima, Professor
Faculty of Engineering
Yamagata University

I was delighted when I found out a feature article on superconducting microwave/terahertz wave device technology would be included in the 2006 Spring issue of Superconductivity Web21 because it is such a timely subject. In the field of superconducting devices, analog radio-frequency devices were expected to be commercialized first, but I had become slightly uneasy at the lack of progress. But now to my relief, a number of practical-level devices are finally being proposed, and not only from the United States. Since this issue will provide detailed information on filters for fourth-generation mobile communication base stations and terahertz imaging technology that uses superconducting tunnel junctions, I would like to introduce the recent status in other areas. In the microwave band, reception filter systems for cellular phone base stations are, most likely, the main application. Recently, Prof. Cao's group (Tsinghua University) reported the results of a field test on a superconducting filter system for an 830 MHz cellular phone base station. They obtained good results by placing a 14-channel HTS filter system on three base stations, and are currently preparing to place a 30-channel HTS filter system on five base stations. The long-term stability and improved communication quality of superconducting filter systems has been proven, and their future spread in China can be expected. As for other applications, Prof. Lancaster's group (the University of Birmingham) in United Kingdom is proposing a superconducting filter system that reduces noise in urban areas to improve the sensitivity of radio astronomy. They have announced that their use of superconducting filters dramatically raises the sensitivity of radio telescopes. This same finding was also announced two years ago by Japan's National Institute of Information and Communications Technology. The institute incorporated a 2 GHz band superconducting bandpass filter system from DENSO Corporation into the 34 m parabolic antenna for radio astronomy in Kashima, and this has reportedly been successful in eliminating noise from adjacent frequencies and building a system that can pick up extremely weak radio waves. Superconducting bandpass filters are extremely effective at reducing urban noise and preventing interference from radio communications, and the expansion of applications in that area can also be expected. In addition, the superconducting filter system for relay base stations used in digital terrestrial television broadcasting, which is being developed by Toshiba and NHK, looks promising, and future advances can be expected.

At this point in time, the most typical application in the sub-millimeter to terahertz band is SIS mixers used in radio astronomy. The building of a large radio astronomy facility in Chile's Atacama Desert is being pushed forward with international collaboration, and a decision has been reached to incorporate a superconducting mixer there. Along with the large facility, a transportable sub-millimeter wave radio telescope will also be installed, and a Japanese group has already installed an SIS mixer for observing the 492 GHz spectrum and is successfully observing good spectra.

A large number of microwave/terahertz wave superconducting devices have already been commercialized, while many more are currently being studied or manufactured on a trial basis. I truly hope that superconducting devices will one day be a common part of our daily lives.

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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology - Development and IMD3 Evaluation of Superconducting Filters for Transmissions over Next-Generation Mobile Communications Base Stations -

Akihiko Akasegawa, Kazunori Yamanaka, Manabu Kai, Teru Nakanishi
Fujitsu Limited

Superconducting filters, which can deliver sharp frequency cut-off characteristics with low loss, can be applied to the receiver front-end of mobile communications base stations. However, if they can be applied to the transmitter front-end, their commercialization is expected to expand. In this feature article, we will introduce some of our research and development on superconducting filters for transmission through next-generation mobile communications base stations.

We studied a superconducting filter with a 0.1 GHz bandwidth and 4 GHz center frequency as a candidate for application to a next-generation mobile communications system that will enable high-speed transmission at 100 Mbit/s or more.[1)] Introducing a superconducting filter to the output destination of a transmission power amp makes it possible to suppress sideband leakage due to the amp's nonlinearity, and benefits such as effective frequency usage and increased transmission efficiency can be expected.[2)] However, when we input RF high-power of several watts to several tens of watts to that superconducting filter, the power handling capability is low, including the occurrence of the quench phenomenon, with the small microstrip line filters that are used in receiving filters. In addition, when there is nonlinearity in the filter circuit, distorted waves, particularly third-order intermodulation distortion (IMD3), occur in-band and out-band, just as in the power amp, and this becomes a serious problem in mobile communications.[3)] Meanwhile, a filter as small as possible is desirable when considering such things as lessening the load on the cryocooler, but there tends to be a tradeoff between RF power characteristics and size reduction, and therefore, ingenuity in structure design, implementations, and other areas is required to achieve a satisfying superconducting filter for transmission from a practical standpoint.

Consequently, we selected a TM_{11} mode disk-type resonator that can ease current crowding, and a high power handling capability and lower IMD3 characteristics were obtained by forming an upper dielectric layer on this resonator pattern.[4)] Furthermore, using this upper dielectric layer, we provided a conducting layer for dual-mode generation, and made progress in increasing the stages and reducing the size of filters.[5)] In the superconducting filter package shown in Fig. 1, we placed two 4 GHz band TM_{11} mode disk-type resonators with a YBCO film/MgO substrate configuration and then we built up a $LaAlO_3$ dielectric that has a small disk pattern of superconducting film for dual-mode generation. This enabled us to obtain a small filter of which the cut-off characteristics near the passing end correspond to three or four times the number of resonators when the resonators are simply connected in tandem, and we confirmed this in actual prototype manufacturing as well.[6)] In addition, when evaluating the power handling capability and IMD3 characteristics of our prototype filter by inputting a continuous wave (CW) up to 10 W, we were able to maintain low loss at 70K and obtain a low distortion characteristic of -60 dBc or less against fundamental waves.[7)]

Fig. 1 4 GHz band superconducting high-power filter

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Please note that a portion of this research was carried out based on the "Research and Development of Advanced Radio Signal Processing Technology for Mobile Communications Systems" commissioned by the National Institute of Information and Communications Technology (NICT) of Japan.

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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology - Power Handling Characteristics of High-Temperature Superconducting Film for Use in Superconducting Filters for Transmission -

Haruhiko Obara
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It is widely known that receiving filters using high-temperature superconducting film, which are used in mobile communications base stations for cellular phones and the like, were first successfully put into practical use in the field of high-temperature superconducting electronics. Thanks to their high operating temperature, born of high-temperature superconductivity, and the superior low loss characteristics not possible with conventional filters, it is thought that the implementation of highly reliable systems delivering high performance and using small cryocoolers will lead to the practical application of these sorts of superconducting microwave devices. However, only a small number of venture companies in the United States have so far succeeding in commercialization, and the truth is we have not seen as large a market expansion as was initially expected.

Consequently, the enabling of superconductivity in not only receiving, but also transmitting, devices is being studied to further raise the effectiveness of superconducting microwave device deployment. A typical example is a transmitting filter. The introduction of superconducting filters for transmission can be expected to reduce the power of transmission amps and lower out-of-band electromagnetic leakage, thanks to their low loss and excellent frequency characteristics. However, devices for transmission must have an excellent power handling capability, because higher-powered microwaves pass through them than through receiving devices.

The power handling capability of superconducting devices must be evaluated at a variety of levels, including film, device, and system. In this article, I will focus on the power handling capability of superconducting film. With superconducting microwave devices, microwaves are basically reflected by the shielding current flowing near the film's surface (range of penetration depth of superconductivity). Consequently, the power handling capability of superconducting film is sensitive to the properties of the film's surface or the boundary with the dielectric substrate. The figure shows the microwave-power-dependent measurement results of surface resistance (basic parameter that decides superconducting microwave device loss) for a superconducting film that has differing surface morphologies. You can see that the rougher the surface morphology is, the larger the power dependency will be. Such a large power dependency will manifest as nonlinearity of the superconducting film against microwaves, resulting in serious problems for the advanced digital communications of today, including signal distortion and out-of-band electromagnetic leakage.

Even with superconducting film that exhibits excellent characteristics near single crystals, non-linearity due to so-called d-wave superconductivity has in recent years been shown to occur. Since it is beyond the scope of this article to go into the details, I would like to refer interested readers to Reference 1 below. For d-wave superconductivity, the superconducting gap is not opened depending on the direction of current flow. Consequently, power dependency arises in surface resistance, even with low power microwaves, resulting in non-linearity. This effect becomes even more pronounced at lower temperatures.

Today, fabrication technology for good high-temperature superconducting film is becoming established, and the non-linearity due to surface morphology I discussed in this article has nearly been conquered. In addition, there is fortunately no marked effect of d-wave superconductivity at the operating temperature (60K to 80K) of superconducting devices that use small cryocoolers. Devices for superconducting

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transmission are conquering a variety of issues thanks to tireless research and development. Transmission device research is now shifting to device shapes with superior power handling, and the development of systems that include everything up to a cryocooler. We can expect an even larger market if we succeed in enabling superconductivity for transmitting/receiving devices in the field of communications. In particular, excellent research results are being reported from Japan, and I would like to think that superconducting microwave devices will enjoy ever-expanding practical use in an even wider range of fields.

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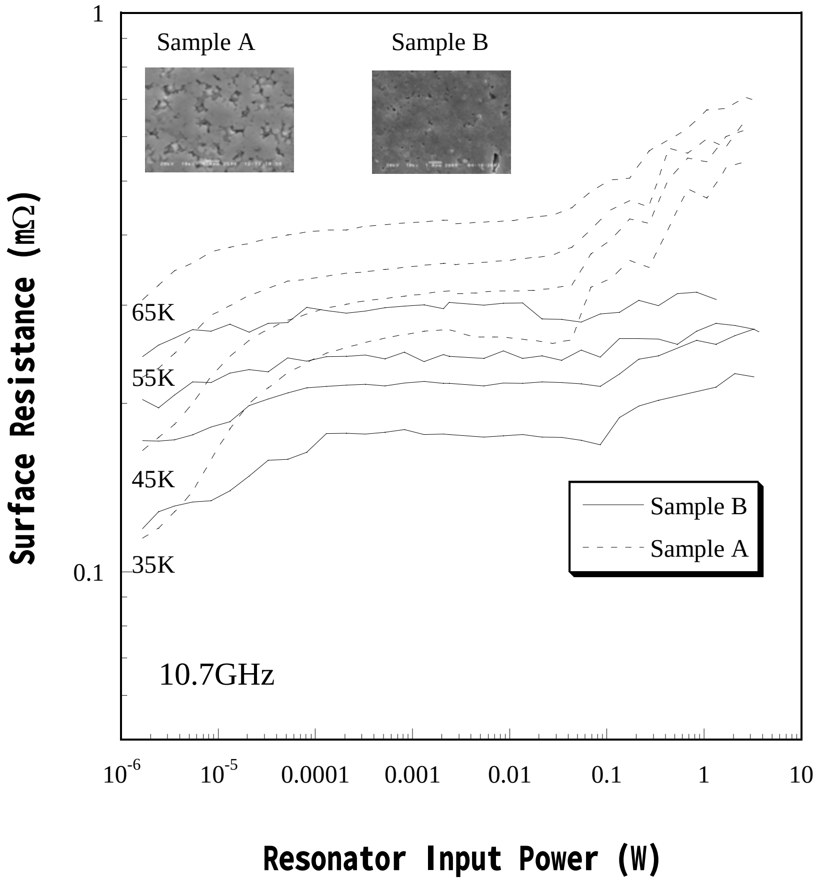

Measurement results for the power-handling capability of superconducting film with differing surface morphology (the photo is an SEM image of the film's surface). The x-axis is the microwave power input to the dielectric resonator used in measurement. The y-axis is the surface resistance of the superconducting film. Sample A (dotted line), which has a rough surface morphology, exhibits a larger power dependency.

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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology - JIS H 7307:2005 "Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies" and Maintenance Items -

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

JIS H 7307:2005 "Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies," the first JIS standard in the field of superconducting electronics applications, was drafted and carefully discussed as a standard consistent with the IEC international standard IEC61788-7 "Superconductivity - Part 7: Electronic characteristic measurements – Surface resistance of superconductors at microwave frequencies" (issued in 2002). Enacted in February 2005, JIS H 7307:2005 provides a test standard for measuring the surface resistance of superconducting film, a key parameter controlling the performance of, for example, high-temperature superconducting microwave filters, which are being considered for installation in mobile communications base stations. The main measurement specs are a frequency range of 8 GHz to 30 GHz, a measurement resolution of 0.01 mΩ (10 GHz basis), a measurement temperature range of 30K to 80K, and a coefficient of variation (standard deviation divided by mean value) value of less than 20%.

Two resonator methods are employed in this test method. The dielectric cylindrical resonators are formed by sandwiching sapphire rods with extremely low dielectric loss between two pieces of superconducting film and then measuring the Q value of these resonators. The surface resistance of the superconducting film is computed based on the Q values of the two resonators, composed of sapphire rods which have equal diameters and a length ratio of 1:3. To measure extremely low surface resistance on the order of 0.1 mΩ (10 GHz basis) precisely, the size (diameter and length) of the sapphire rods and the structure of the dielectric cylindrical resonators are crucial, and know-how accumulated through round robin measurement, in which domestic institutions are playing a central role, is being reflected in the standard. In particular, based on resonant mode analysis that takes into consideration the anisotropy of sapphire's dielectric constant, it is becoming clear that more precise measurement would be possible by changing the size of the sapphire rods, although this was not sufficiently clear at the deliberation stage for the IEC international standard. The change in the recommended values for sapphire rod size is planned to be adopted in the IEC international standard maintenance that is currently underway (release planned for November 2006), but in anticipation of this, it has already been described in JIS H 7307's appendix.

In other areas of IEC international standard maintenance, the extension of measurement frequencies (addition of 18 and 22 GHz to the current 12 GHz) is being deliberated. After IEC international standard maintenance ends, this will be reflected in JIS maintenance.

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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology - Potential of Terahertz Electromagnetic Wave Generation Using Intrinsic Josephson Junctions -

Kensuke Nakajima, Professor
Department of Electronic and Information System Engineering
Faculty of Science and Technology, Hirosaki University

Intrinsic Josephson junctions found in high-temperature superconductors with strong anisotropy, such as Bi-2212, in which the current transport characteristic along the c axis of is controlled by the Josephson effect between superconducting CuO_2 layers. Since it is possible to relatively easily create an under damp junction stack with uniform characteristics by microfabrication of high-quality single crystals, there has been a high level of expectation toward applications to ultra high-frequency oscillators that use flux-flow from the very moment of their discovery. Broadly speaking, there are three approaches to ultra high-frequency oscillators by means of intrinsic Josephson junctions. First, there is the method that uses flux-flow oscillation (FFO), which is already being implemented by metallic SIS junctions, such as Nb/AlOx/Nb. Second, there is the method that extracts a portion of the energy that results from the excitation of so-called Josephson plasma in which the Josephson current couples with electromagnetic waves within the junction stack. Finally, there is the method that uses a two-dimensional junction array that includes many intrinsic Josephson junctions to achieve stimulated emission. Recently, K. Kadowaki, et al. (University of Tsukuba) announced that when they attempted to excite Josephson plasma by flux-flow, they detected emissions from an intrinsic Josephson junction near the applied magnetic field 1T using a bolometer. This result strongly suggests the potential for emissions by the second method mentioned above, which was theoretically predicted by M. Tachiki, et al. (National Institute for Material Science), and the identification of oscillatory frequencies by such means as spectrometers can be expected in the future.

In addition, Wang, et al. (National Institute for Material Science) discovered from the I-V characteristic that electromagnetic waves that resonate at about 340 GHz within intrinsic Josephson joints that applied a 2.8T magnetic field are excited. Wang and his team are aiming for Josephson stimulated emission by the

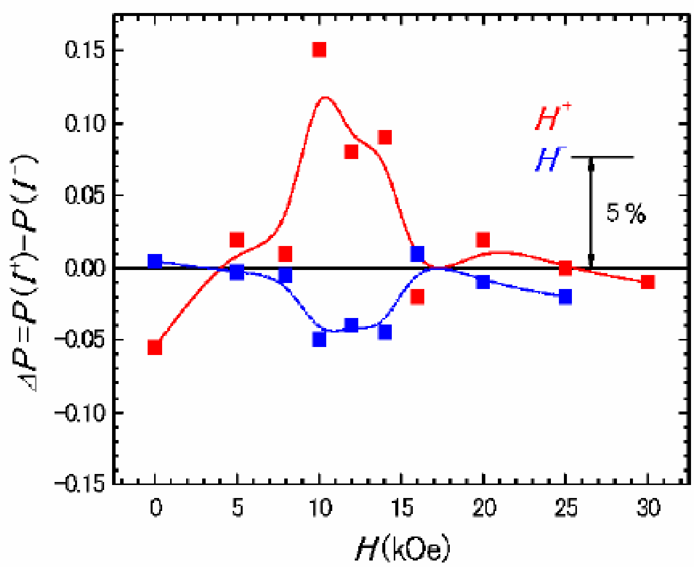

Fig. 1 Emissions from Josephson plasma and estimatable magnetic field-direction (H^+, H^-) dependency of power ΔP.
A power difference reflecting differing flux-flow direction near 1T can be seen.
Source: K. Kadowaki, Sci. Technol. Adv. Matter 6 (2005), p. 589-603;
K. Kadowaki, I. Kakeya, T. Yamamoto, T. Yamazaki, M. Kohri and Y. Kubo, Physica C, in press.

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third method mentioned above, in which many Josephson junctions in the two dimensional array are synchronized.

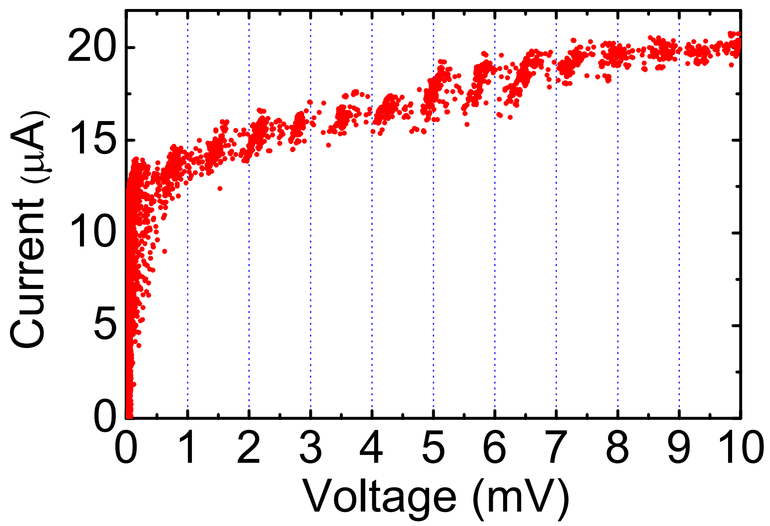

Fig. 2 Typical current-voltage characteristics of sub-micron intrinsic Josephson junctions with a width of 0.6 μm. Evenly-spaced current steps with an interval of ~700 mV at 2.8 T have been observed, indicating that electromagnetic wave resonance at ~340 GHz has been excited in IJJs. These steps are observable up to 40 K.
This figure is provided by courtesy of Dr. Wang, NIMS, Tsukuba.

Thanks to advances in this sort of research, in the future we can readily expect it to be possible to achieve superconducting terahertz wave sources that are superior in terms of power and variable frequency range for quantum cascade lasers (QCL), which seem ahead of their time, and Bloch oscillators.

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Feature Articles: Superconducting Microwave/Terahertz Wave Device Technology
- Terahertz Imaging Technology Using Superconducting Tunnel Junctions -

Seiichiro Ariyoshi, Chiko Otani, Hiromi Sato
The Institute of Physical and Chemical Research (RIKEN)

Terahertz wave, which is located at the boundary between radio waves and light waves, is expected to be a crucial frequency band in such activities as non-destructive inspection in the field of industry, cancer diagnosis, analysis of structures within organisms, and observational research on galaxy formation and evolution in the field of astronomy. However, the multi-element detection technology necessary for performing highly sensitive and large-scale imaging in this band has yet to be developed. In response, we are pushing ahead with R&D on a super high-sensitivity direct detector for a wideband terahertz wave using superconducting tunnel junctions (STJ) and making an imaging array out it. One pixel of the detector takes a structure that uses STJ elements to mediate between the flat antenna of a niobium superconductor and a superconducting microstrip line (Fig. 1). The gap energy of the superconductor is several meV, and since this is equivalent to a photon frequency of several 100 GHz, terahertz, wave detection will be possible. Since STJ elements operate electrically as resistance and capacitance, and parallel circuits and superconducting microstrip lines as inductance, the detector overall comprises a type of LCR circuit, and several narrowband resonance frequency peaks emerge. Optimizing the size, position, critical current density, and other aspects of STJ elements makes it possible to control these resonance frequencies, and this enables the creation of a detector with about 10% of the bandwidth that has the desired center frequency. The center frequency for now is being set to 0.65 THz in line with the atmospheric transmittance window of sites suited for astronomical observation. In addition, detector sensitivity is reaching 10^{-16} W/√Hz

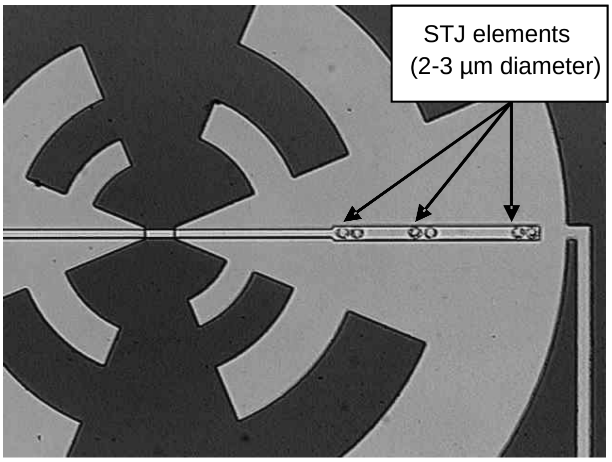

Fig. 1 Microscope photograph of an STJ direct detector.
Linearly distributed STJs are integrated on two wings of a log-periodic antenna, whose radius is about 140 um.

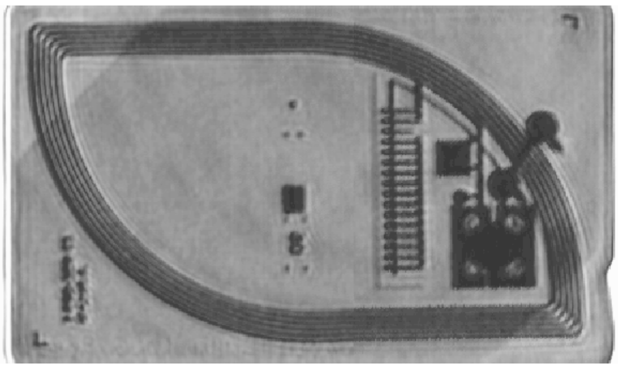

Fig. 2 Terahertz image of a railway payment IC card (ICOCA)
This card is 50 mm by 85 mm in size and 1 mm thick. The scanning step is 200 um. The total acquisition time using the one-pixel STJ detector was about 60 minutes. Improvement of the data acquisition system as well as multipixel STJ detectors are expected to shorten the total acquisition time considerably.

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at noise equivalent power (NEP) under a low background.[1)]

As the first step in imaging development, we are using a terahertz continuous wave source (backward-wave oscillator, BWO) and imaging system[2)] developed by RIKEN, and we are enjoying success in the first terahertz imaging using an STJ detector (one pixel). Fig. 2 is an example of the terahertz transmission image we acquired. As a result of adjusting the STJ detector and light source and eliminating noise to improve image quality, we are now getting a S/N ratio 3.5 figures higher than conventional pyroelectric detectors. The spatial resolution of the images is about 0.6 mm, and they are near the optical diffraction limit that we used.

In the future, we would like to develop even wider application fields by creating a simple cryocooling system and large-scale array of detectors. To create a detector array (100 pixels to start with), we have already fabricated a maximum 6 x 6 = 36 pixel array and started imaging tests using multiple elements, and we later plan on carrying out field analysis for array arrangements and optimization including peripheral optics. In addition, we are planning the development of multicolor (multiwavelength) detector arrays that make the most of the band-selectable frequency characteristics of detectors. In building a highly sensitive detection system, we aim to introduce a new mechanical cryocooler that does not require a cryogen (liquid helium), and to build a simple cryocooling system that can operate continuously.

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Patent Information

Introduction of Published Unexamined Patents in the 3rd Quarter of Fiscal 2005

The following are ISTEC's patents published from October to December 2005. For more information, access the homepage of the Japan Patent Office and visit the Industrial Property Digital Library (IPDL).

1) Publication No. 2005-274485: "Superconductive sampler circuit"

Conventional superconductive sampler circuits comprised of a sampling pulse generation circuit, comparator circuit, and output read out circuit, have the issues of irregular operations such that the reset pulses in the sampling pulse generation circuit tend to be in the comparator circuit, and the output read out circuit can't being properly reset. This invention solves the aforementioned issues by adding an escape gate Josephson junction to the sampling pulse generation circuit and a reset Josephson junction to the read out circuit, as well as supplying suitable bias currents for those circuits.

2) Publication No. 2005-291707: "Magnetic information reading/evaluating method and device"

This patent relates to the magneto-optical (MO) imaging technique that observes an object's magnetic field using the magneto-optical effect and then the magnetic field is visually evaluated two dimensionally. This invention employs a magneto-optical medium that is made up of Bi-substituted iron garnet film, represented by the below chemical formula, on the specified crystal surface of a garnet single-crystal substrate. This medium possesses in-plane magnetizing characteristics, enabling the imaging of the magnetic distribution at a high resolution.

Chemical formula: $(Bi_wR_{1-w-x}Pb_x)_3(M_yFe_{1-y})_5O_{12}$

where: R is one or two selected from Lu and Yb, M is one or two selected from Ga and Al, and w, x and y satisfy the following formula:

$0.25 \leqq w \leqq 0.7$, $0 \leqq x \leqq 0.05$, $0 \leqq y \leqq 0.24$

3) Publication No. 2005-292163: "Magneto-optical medium and the manufacturing method thereof"

This invention relates to provide a magneto-optical film for a magnetic sensor, that has an easy magnetization axis parallel to the film surface, a large Faraday effect, and high spatial resolution. This invention discloses the in-plane oriented magnetic film that is epitaxially grown Bi-substituted iron garnet film, represented by the below chemical formula, on the specified crystal surface of a single-crystal garnet substrate, as well as its manufacturing method.

Chemical formula: $(Bi_wR_{1-w-x}Pb_x)_3(M_yFe_{1-y})_5O_{12}$

where: R is one or two selected from Lu and Yb, M is one or two selected from Ga and Al, and w, x and y satisfy the following formula:

$0.25 \leqq w \leqq 0.7$, $0 \leqq x \leqq 0.05$, $0 \leqq y \leqq 0.24$

4) Publication No. 2005-308465: "Measurement method and measurement system for the n value of superconductors"

This invention provides a non-destructive, non-contact method for finding the n value, which indicates the characteristics of the transition region, of a superconductor. In a method that spatially detects the currents induced on the surface of a superconductor specimen by some applied external AC magnetic fields and then estimates the current-voltage characteristics of the superconductor, this invention identifies the n value by the following procedure:

(a) To generate a magnetic field, apply an external AC magnetic field of at least two different frequencies ($f_1, f_2 : f_2 > f_1$) to a superconductor while continuously varying current Id, detect the third harmonic component W of the current induced on the surface of the superconductor, and then acquire at least two W-Id curves.
(b) Calculate similitude ratio β for at least two of the aforementioned W-Id curves.
(c) Calculate n value using the similitude ratio β, the two frequencies (f_1, f_2) and the following formula:

$$n=\{(\log f_2-\log f_1)/\log \beta\}+1.$$

5) Publication No. 2005-310600: "Manufacturing method for MgB_2 wires"

This invention relates to the manufacturing method for intermetallic compound superconductor MgB_2 wires with a critical temperature of Tc = 39K. This invention is characterized by the use of MgB_2 compound powder and Mg and B powder as raw materials in the sealed tube method, and MgB_2 wires are manufactured by means of the following process:

(a) Prepare the raw material mixture by combining powdered Mg and B with MgB_2 powder.
(b) Prepare pellets of the aforementioned mixture by compression molding.
(c) Seal the aforementioned pellets in a metal tube.
(d) Reform the aforementioned metal tube to a wire form by drawing.
(e) Apply a specified heat treatment the aforementioned wire in a pressurized inert gas atmosphere.

6) Publication No. 2005-328370: "Superconducting multi-stage sigma-delta modulator"

This invention relates to the structure of a high-level superconducting Σ-Δ modulator. Conventionally, a complex circuit, such as a feedback driver circuit that feeds back multiple single flux quantum (SFQ) pulses, was used to implement multi-stage Σ-Δ modulator of SFQ circuits. With this invention, there are superconducting Σ-Δ modulator no.1, which is comprised of integrator no.1 and comparator no.1, and outputs a Σ-Δ modulation signal, and superconducting Σ-Δ modulator no.2, which is comprised of integrator no.2 and comparator no.2 and outputs a Σ-Δ modulation signal. This patent discloses the multi-stage superconducting Σ-Δ modulator that takes the output of integrator no.1 as the input for integrator no.2 by means of magnetic coupling.

7) Publication No. 2005-328371: "Superconducting Circuit"

A superconducting circuit for ultra-high-speed operation generates ultra-high-speed internal clock signals by multiplying the external clock signal that is supplied from outside the circuit. When a ladder circuit is used for this multiplication circuit, degradations in performance and operation margin, caused by unevenness in the interval of clock signals, cannot be avoided. In this invention, three Josephson transfer line circuits, no.1, no.2, no.3, connected in a series, are provided. Josephson transfer line circuit no.2 employs a smaller bias current and larger inductance than Josephson transfer line circuits no.1 and 3, and it equalizes the pulse interval by slowing or delaying the input single flux quantum pulses that were.

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

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Standardization Activities

Topics in December

- The 10th IEC/TC90 Superconductivity International Congress 2006 to be held in Kyoto -

The 10th IEC/TC90 Superconductivity International Congress 2006 to be held in Kyoto from June 6 to 8, 2006 was officially announced on the IEC Web site (IEC Working documents for TC90) (Administrative Circular 90/180/AC) on November 18, 2005. The site also provides general information, including information on the venue, schedule, registration, and accommodations.

The following is a general overview of the 10th IEC/TC90 Superconductivity International Congress:

- Technical committee name: IEC/TC90 (Superconductivity)
- Venue: Kyoto University Clock Tower Centennial Hall
  Yoshida-Honmachi, Sakyo-ku, Kyoto-shi, Kyoto, Japan 606-8501
  Phone: 075-753-2285
  Fax: 075-753-2286
  URL: http://www.kyoto-u.ac.jp/top2/11-top.htm
- Date: June 6 to 8, 2006
- Schedule:
  06-06-2006 WG2, WG3, WG7, Ad hoc G1, WG4, WG11, and WG8
  06-07-2006 WG5, Ad hoc G2, and WG9
  06-08-2006 TC90 Plenary
- Registration deadline: April 15, 2006
- Recommended accommodations:
  - Hotel Fujita Kyoto -
  Kamogawa Nijo-ohashi Tamoto, Nakagyo-ku, Kyoto-shi, Kyoto, Japan 604-0902
  Phone: 075-222-1511
  Fax: 075-222-1515
  E-mail: room-yoyaku@fujita-kyoto.com
  URL: http://www.fujita-kyoto.com

  - Kyoto Hotel Okura -
  Kawaramachi-Oike, Nakagyo-ku, Kyoto-shi, Kyoto, Japan 604-8558
  Phone: 075-211-5111
  Fax: 075-221-7770
  E-mail: webmast1@kyotohotel.co.jp
  URL: http://www.kyotohotel.co.jp
- Reservations deadline: April 15, 2006 (direct reservations)

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Topics in January

- NEDO Commissions ISTEC to Conduct a "Study on the Standardization of the Technical Base of Superconducting Electronic Elements"

On December 1, 2005, the New Energy and Industrial Technology Development Organization (NEDO) commissioned the International Superconductivity Technology Center (ISTEC) to conduct a "Study on the Standardization of the Technical Base of Superconducting Electronic Elements."

The work commissioned is as follows:

Purpose

Electronics that employ the phenomenon of superconductivity are generally referred to as superconducting electronics, and research and develop is underway for creating practical superconducting electronic devices that are faster, consume less power, and deliver higher sensitivity than semiconductor electronics. The superconducting elements that comprise superconducting electronics are broadly classified into passive elements, such as frequency filters and magnetic shields, and active elements, such as Josephson elements. Josephson elements, in particular, are crucial elements that serve as the foundation for superconducting quantum interference device (SQUID) elements used in the fields of diagnostics and medicine, and single flux quantum (SFQ) circuits used in the fields of information and communications. Superconducting standardization in Japan began in 1986 and mainly focused on the related term standards and basic test method standards. Market expansion for products using low-temperature superconducting materials, as well as for telecommunications equipment using high-temperature superconductors, is expected, and international standardization of products, primarily in Japan, is being demanded. As part of the standardization of the technical base of superconducting electronic elements, primarily Josephson elements, this study will examine, in partnership with other ongoing projects, technical information concerning the basic characteristics of Josephson elements and the standardization of applicable devices, and create draft documents of international standards.

Study Content

This study will organize a research committee of key figures and undertake the following studies based on related technological advances in Japan and abroad.

Study 1 Creation of an informative draft on test methods for the basic characteristics of Josephson elements

Japanese and international test methods for the basic characteristics of Josephson elements will be studied and put into international document form as a draft report on test methods.

Study 2 Extraction of test items for functional characteristics of applicable devices for Josephson elements

Extract test items for functional characteristics of devices that apply SQUIDs, high-frequency response, x-ray spectroscopic response, mass spectroscopic response, and Josephson elements such as SFQ circuits, and contribute to international standards documentation as a draft report on general requirements for the testing of Josephson element characteristics.

Study 3 Creation of international standards drafts and JIS draft outlines and international/domestic standardization activities

Study trends in domestic/international superconducting electronics technology and the needs for international and JIS standardization over a three-year period, and contribute to international standardization activities.

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Study Term

This study shall run from FY2005 to FY2007.

Research System

This study will be carried out by a technical study committee chaired by M. Okubo (National Institute of Advanced Industrial Science and Technology (AIST)), and a draft report subcommittee headed by K. Tsukada (Okayama University).

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(Yasuzo Tanaka, Director, Standardization Department, ISTEC)

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