

New Year Message

Happy New Year! More than a year has passed since the advent of the 21st century. In the 15 years since the discovery of superconductivity in 1986, Japan, Europe, and the United States have been mobilizing resources in research and development projects for the practical application of superconductivity.

ISTEC has been commissioned by the Government of Japan to carry out a number of national projects on superconductivity. The projects include "Research and Development on Basic Technologies required for Superconductivity Applications"; "Technological Development of a Superconducting Power Storage System"; and "Research and Development of a Superconducting Bearing Technology for a Flywheel Power Storage System". Since then, ISTEC has been playing the key role in the R&D projects on superconductivity in Japan in cooperation with and with support from member companies and organizations.

The circumstances surrounding R&D on superconductivity are changing. For example, ISTEC has been coping with environment problems, energy-saving issues, and information technology. Although practical application of superconductivity technology is expected in the near future, we still need time to continue our R&D efforts.

In cooperation with the academic, industrial, and administrative circles, ISTEC is determined to speed up R&D projects on superconductivity application technologies during the year 2002. I sincerely hope for the continuing success of all member companies and organizations, and also would like to ask for your continuing support and cooperation. (Hiroshi Araki, President, ISTEC)

This information has been available in Japanese on the "Superconductivity Web 21" site at <http://www.istec.or.jp> since January, 2002.

Aspirations for the Year 2002

The year 2001 was the first year of the 21st century and people expected something good to remember. However, the reality was different. The world economy continued to be stagnant during the year and, then suddenly, the September 11 terrorist attacks occurred in the United States. It seems that today we live in an age where problems in the world economy, accumulated over the past decades, have arisen and many of the current technological systems have reached a mature stage. Thus, people on earth are being urged to mobilize all of their wisdom to change and solve global issues, for example, environmental problems and energy issues.

Because many people are concerned with whether superconductivity technology can provide a solution to these global problems, we have to do everything we can to meet their expectations.

Some 15 years have passed since superconductivity was discovered in 1986. High temperature superconductor technology is now going to blossom in Japan; superconducting bulk, wires, and devices have made remarkable advancements over the past several years, and their practical

applications are at hand. These advancements imply that R&D on superconductivity has successfully developed a means of making high temperature superconductors, which are complicated materials and extremely difficult to produce. In other words, we have gained a method for producing superconducting materials, leaving the scientific research material stage behind, and ongoing developments are also expected in the near future.

I am sure all of those concerned with superconductivity are determined to achieve substantial results to make the year 2002 significant.

(Shoji Tanaka, Director General, SRL/ISTEC)

This information has been available in Japanese on the "Superconductivity Web 21" site at <http://www.istec.or.jp> since January 2002.

Contents (Spring,2002)

New Year Message	1
Aspirations for the Year 2002	1
Outlook for the Development of Superconductivity Technology	2
Aspirations for the Year 2002	2
Aspirations for the Year 2002: Research at the Superconducting Material Center	2
Necessity Is the Mother of Invention	3
Aspirations for the Year 2002	3
My First Dream of the New Year	3
Aspiration for the Year 2002	3
Aspirations for the Year 2002	3
Aspirations for the Year 2002	4
Superconducting Products Guide	4
Purpose of the Superconducting Magnetic Bearing Technology Research and Development for Flywheel Power Storage	4
Design of a 10 kWh Class Flywheel System	5
The Trend in Flywheel Units	5
Present Status of Bulk Superconductors for Bearings	5
Current Situation of LTS Generator Development	6
Current Status of HTS Motor Development	6
Superconductivity Related Research and Development Program in the Republic of Korea	7
Superconductivity Related Research and Development Programs in EU	8
Report of 2001 Japan-EU Workshop on Superconductivity	9
SRL Director General Awards for Autumn 2001	9
65th Meeting on the Cryogenics and Superconductivity in Autumn 2001	9
Topics on Applied Superconductivity Research Symposium	10
Way to the Quantum Computer	11
Superconductivity by Field Effect Doping	11
Development of a Conjunction Technology Led to Successful Development of an Ultra Strong Bulk Superconducting Magnet	12
One-Step Advanced Superconducting A-D Convertor	12
Patent Information-from December 2001 to February 2002-	13
Standardization Activities	14

Outlook for the Development of Superconductivity Technology

Takamichi Hamada, Deputy Director-General, Industrial Science and Technology Policy, Ministry of Economy, Trade and Industry (METI)

A new year has begun amidst severe economic conditions. It seems an increasing number of people are expecting technological development and breakthroughs these days to overcome the situation.

The Government of Japan, centering on the General Council on Science and Technology, has been trying to improve budget allocations for science and technology and reform the current innovation systems. Meanwhile, an annual total of 10 trillion yen is invested in research and development programs in the private sector. Thus, my strongest concern at present is to find the answer to the question of why the private sector has been unable to form a new industrial market despite the huge amount of investment in their R&D programs. To find the answer, we have set up a Technology Innovation System Subcommittee under the Industrial Structure Council and asked the members to discuss how to manage technology and how to subsidize capital investment in facilities for the prototype machine stage. However, I have not yet received a report that answers my question.

An increasing number of people are hoping for technological development and breakthroughs. At the same time, they are expecting more definitive results from R&D projects in a short period. Considering the severe economic conditions, this trend is probably unavoidable.

Considering the nature of the research, the technological development of superconductivity should be dealt with over the medium- and long-term ranges. However, the hurried trend is prevailing in superconductivity R&D activities, including the analyses of the high temperature superconducting mechanism and of the correlation between material compositions and the functions. In reviewing the superconductivity projects, therefore, we will have to define and set goals over the short- and medium-term periods to utilize R&D results for practical applications.

Based on the past development results and trends in competitive technologies, we will need to examine the present selections and put emphasis on power related projects, including superconductivity power generation, transmission cable, and power storage systems. At the same time, we will need to explore new fields. An example is to utilize the characteristics of superconductivity, including applications of our linear motor technology to transportation equipment, space systems, telecommunications equipment, and to device development.

I think that now is the time that people engaging in the technological development programs on superconductivity should discuss openly and reach a consensus before drawing a definite conclusion on the R&D direction of superconductivity in the future.

This information has been available in Japanese on the "Superconductivity Web 21" site at <http://www.istec.or.jp> since January 2002.

Aspirations for the Year 2002

Shin Kosaka, Deputy Director, Energy Electronics Institute, National Institute of Advanced Industrial Science and Technology

Happy New Year!

The year 2001 saw a major reform in terms of organization, personnel, and budget—the National Institute of Advanced Industrial Science and Technology, an independent administrative institution, was formed in April 2001 after consolidating 15 research institutes under the former Agency of Industrial Science and Technology. Superconductivity power application technology related research programs will continue under the Energy Electronics Institute, which mainly undertakes energy and environmental technology research and development. Thus, the year 2002 must bring about some results to demonstrate that the new organization functions well. Centering on the main research subjects of long-distance cooling technology of superconducting power transmission cable and large area superconducting thin film growth technology for fault current limiters, we will expand cooperation with the academic and industrial circles to promote steady R&D for the practical applications of superconductivity. We are well aware of and encouraged by the news and topics on possible superconductivity business in Japan and overseas, which are introduced on the "Superconductivity Web 21" site. We strongly hope to contribute to the formation of new business opportunities.

Aspirations for the Year 2002: Research at the Superconducting Material Center

Eiji Takayama-Muromachi, Director, Superconducting Material Center, National Institute for Materials Science

The "Superconducting Material Center" was formed on October 15, 2001 as a new research organization under the National Institute for Materials Science, an independent administrative agency. The center mobilizes organizational resources to conduct a comprehensive research on a wide range of topics from basics to applications. Thus, R&D activities include various superconducting systems such as oxides, metals and new metals like MgB₂, and a variety of research fields such as exploration of new materials, evaluation of physical properties and crystal structures, development of superconducting wires, thin-film and single-crystal growth, superconducting devices like SQUID, and development of a strong magnets applicable to, for example, magnetic separation and NMR.

The center encompasses some 25 researchers from the National Institute for Materials Science. In addition, the center has invited research leaders and advisors from universities and business organizations to play the central role on superconductivity research.

We see the year 2002 as the time to sail forth into the world, and are ready to mobilize all of our resources. We appreciate your continuing support.

Necessity Is the Mother of Invention

Kozo Osamura, Professor, Material Engineering, Department of Materials Science and Engineering, Kyoto University

Since a high temperature oxide superconductor was discovered in 1986, a few superconducting materials have been gradually industrialized such as Bi2212 wires, Bi2223 tape and YBCO coated conductors. For example, a more than 1 km long Bi2223 tape can be now produced, but its performance is not yet sufficient.

If a Bi2223 single phase is realized and if a specimen includes perfectly no voids and has good texture within 5 degrees of tilt angle, the critical current density will become 100,000 A/cm² or more and the fracture strength will also improve five times more than the current 130MPa. In other words, a so-called third generation tape is available. When this is realized, the Bi2223 tape wire will deserve true industrialization. However, the production method is still not made clear. I think now is the time that we must stand firm with enthusiasm to manufacture such a tape.

Aspirations for the Year 2002

Shin-ichiro Meguro, General Manager, Superconducting Products Department, Research and Development Division, The Furukawa Electric Co., Ltd.

In the first ten years of the 20th century, people witnessed the formation of the quantum theory and the theory of relativity, both of which are the cores of modern science. Superconductivity was also discovered in the same period. In the first ten years of the 21st century, I hope for some innovative theories and technological breakthroughs in superconductivity. Room temperature superconductivity may seem like a dream now but if we make an epoch-making breakthrough in low temperature or high temperature superconductor technology, we can contribute to the sustainable development needs of people around the world. As a superconducting wire manufacturer, Furukawa Electric is striving to play a part in such technological innovation.

My First Dream of the New Year

Ken-ichi Sato, Chief Engineer, Energy and Environment Technology Laboratory, Sumitomo Electric Industries, Ltd.

Kuma-san: Ohya-san, Happy New Year!

Ohya (Landlord): Hello, Kuma-san, Happy New Year! Please, come in. How about some sake?

Kuma-san: Thank you. That would be nice. Oh, this is good.

Ohya: Well, where is Yutaroh?

Kuma-san: He has been very busy since the end of last year and has to work for the company during the new year holidays.

Ohya: He's lucky when you think of the many jobless people now.

Kuma-san: It's true. Yutaroh has told me of superconductivity. He also told me it is a dreamy technology. But it will take much time before making money.

Ohya: I once heard of it. Japan pioneered it. The government

has set a national goal of building a science and technology based nation, and is spending a lot of money on promising fields. So let's wait and see what Yutaroh is doing. He seems to be working on the material. That's the starting point. I think Japan is doing quite well.

Aspiration for the Year 2002

Mitsunobu Wakata, Head Researcher, Advanced Technology R & D Center, Mitsubishi Electric Corporation

Major issues for Japanese industries is to reduce the high unemployment rate affected by the IT recession in the United States and a worldwide move to ratify the Kyoto Protocol even without the participation of the United States (Japan has to cut over 10% of total emissions of greenhouse gases). A measure to solve these problems at the same time is to boost the superconductivity market, whose size was 250 billion yen in fiscal 2000 and annual growth rate was approx. 10%. I think that boosting the market within several years is very important. The company that I work for has specialized in research and development for the past 40 years and I have worked for the company for 20 years as a researcher. The year 2002 should be the starting point to begin concrete talks.

Aspirations for the Year 2002

Michitaka Ono, Power and Industrial Systems Research and Development Center, Toshiba Corporation

The world's largest high temperature superconducting magnet (1.1MJ of storage energy) finally transposed into superconductivity on December 31, 2000, the last day of the 20th century. The day has become a memorable one for researchers involved in the project. As a developer of the superconducting magnet, we were really moved at witnessing the moment when the coils that we worked on transposed into superconductivity. The motion was rather different from the emotion we had felt when witnessing the rated performance. Unlike the low temperature superconductor project that I worked on, it took 10 minutes before the superconducting transposition completed (until all the coils cooled down below 108K). It was truly a high temperature superconductor!

In the year 2001, we conducted various performance experiments on the magnet. Specifically, we succeeded in achieving 1.1MJ storage energy and confirmed the energy-saving performance and high reliability. These experiments allowed us to make a large step forward to the practical application of a high temperature superconductor.

In the year 2002, I would like to continue working on these results and a series of new projects on high temperature superconductor technology, which will lead to the further development of the superconductive industry. I wish to share my experiences with other researchers involved in superconductivity and hope that people also recognize the wonder of high temperature conductivity.

I would like to continue working on the projects until a room temperature superconductor is realized someday. Then, our efforts will turn in to a wonderful memory to remember

Aspirations for the Year 2002

Kazumasa Takagi, Chief Research Scientist, Advanced Research Laboratory, Hitachi, Limited.

The year 2002 is the last year of the present project, "Collaborative Research and Development of Fundamental Technologies for Superconductivity Application" conducted by ISTE. As one of the researchers in charge of electronics, I think we should pursue higher targets without being satisfied with the achievement of preset targets, including thin film, junction, and circuitry, so far.

There are still many technical subjects to be solved toward the practical application of a high temperature superconductor. I would like to discuss with colleagues in the project the next milestone in research and development on superconductivity and possible practical applications of the results achieved at each stage.

Superconducting Products Guide (Companies are in Japanese alphabetical order)

Bulk material

Polycrystalline substance
Superconducting Material Group, FTP Division, Dowa Mining Co., Ltd.
Phone: 03-3201-1086
FAX: 03-3201-1036
Persons in charge: Nakamura, Wada
Y, Bi, TI systems

Molten substance (Single-domain crystals)
- Superconductivity Group, New Material Research Division, Advanced Technology Research Laboratories, Shin Nippon Steel Corporation
Phone: 0439-80-2714
FAX: 0439-80-2746
e-mail: hirano@re.nsc.co.jp
Person in charge of oxide systems
Trade mark: QMG
- Superconducting Material Group, FTP Division, Dowa Mining Co., Ltd.
Phone: 03-3201-1086
FAX: 03-3201-1036
Persons in charge: Nakamura, Wada
RE systems

Applied products and systems of bulk materials

Magnetic shield
- Superconducting Material Group, FTP Division, Dowa Mining Co., Ltd.
Phone: 03-3201-1086
FAX: 03-3201-1036
Persons in charge: Nakamura, Wada
Y and Bi systems

Current lead
- Superconductivity Group, New Material Research Division, Advanced Technology Research Laboratories, Shin Nippon

Steel Corporation
Phone: 0439-80-2714
FAX: 0439-80-2746
e-mail: hirano@re.nsc.co.jp
Person in charge of oxides

Purpose of the Superconducting Magnetic Bearing Technology Research and Development for Flywheel Power Storage

In recent years, remarkable advancements have been made in the commercialization of flywheel power storage systems to uninterruptible power systems (UPSs) and high quality power supply sources. This is because the flywheel power storage system has many advantages in terms of energy density, repetition number of charge/discharge, reliability, and maintenance, compared with other power storage systems using chemical cells.

As long as an existing mechanical bearing or magnetic bearing is used, the power storage system has a weakness—rotation loss during waiting time. This makes it difficult for the system to store power for a long period of time. Meanwhile, a superconducting bearing, consisting of a high temperature superconducting stator and a permanent magnetic rotor, realizes substantial cut in rotation loss in addition to strong levitation capacity, allowing the system with a flywheel to store power for a relatively longer time.

As a long-term goal, our NEDO project aims to develop a 1 to 10 MWh-class flywheel power storage system to level the difference of power load between daytime and night. And at present, we are working on the R&D of the fundamental technologies. In the first phase, ended in fiscal 1999, we engaged in the R & D of superconducting bearing elemental technologies for 10 kWh class storage systems, and in the making and testing of a 0.5 kWh demonstration system. Our experiments revealed that a radial-type bearing, where the facing normal line of a magnetic circuit and a superconductor is located in the radius direction of the axis, exhibits good performance as the bearing for a bulky heavy things rotating at a high speed.

Based on the findings, in the second phase, started since fiscal 2000, we have been working on the development of element technologies for a 100 kWh class radial-type superconducting magnet bearing and on the development of a 10 kWh demonstration system. Main goals of our element technologies include improvement in levitation force density (10N/cm²), reduction of rotation loss (2mW/N) and how to avoid rotation axis fall to be caused by flux creep.

Concerning the 10 kWh demonstration system, we plan to develop technologies to control vibrations of the axis using magnetic bearings; to develop a reinforced CFRP flywheel; and to design and produce a total system and to perform its operation tests.

Even for a 1 to 10 kWh class compact power storage system, if it can achieve a substantial cut in losses and if it becomes reasonable in economical cost, the ripple effects will be great. For example, the power storage system can replace existing storage systems for high quality power supply. In addition, the system can be applied to natural energy resources such as wind power generation and solar power generation.

(Naoki Koshizuka, Deputy Director General, Morioka Laboratory, SRL/ISTEC)

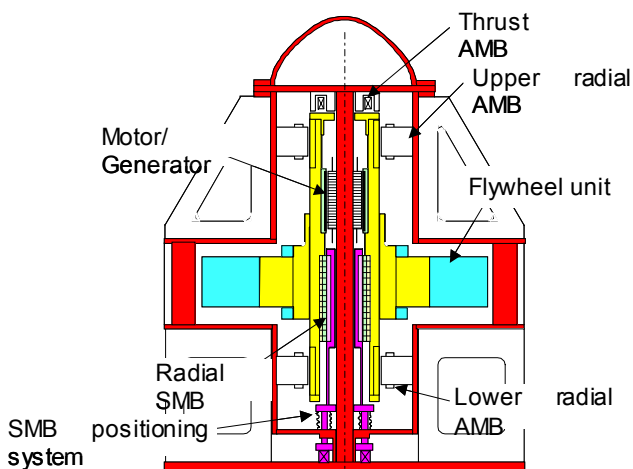
Design of a 10 kWh Class Flywheel System

Osamu Saito, Section Manager, Machine Element Research Department, Fundamental Technology Research Institute, Ishikawajima-Harima Heavy Industries, Ltd.

I would like to introduce to you a 10 kWh class flywheel power storage system using a high temperature SMB (Superconducting Magnetic Bearing). This system has a 1-m diameter CFRP ring fixed on a hollow rotor. A Motor/Generator, installed in the rotor which performs a high speed rotation (15,860 rpm, 830m/s of circumferential speed), converts electrical energy, obtained from the rotations, into rotation energy for storage. Since the flywheel power storage system aims to store energy for a long period of time, windage loss and mechanical loss must be reduced. To this end, the entire flywheel is operated in vacuum and non-contacting condition. The weight of the flywheel is supported by a radial SMB in non-contacting condition. In addition, an AMB (Active Magnetic Bearing) is installed to deter vibrations of the flywheel.

After this power storage system performs factory operation in fiscal 2003, it will be moved to the Shikoku Research Institute Incorporated for long-term operation tests in fiscal 2004 to evaluate the reliability of the SMB and the system.

This project was originally commissioned to ISTEK by NEDO. ISTEK has re-commissioned part of the project for fiscal 2000 to fiscal 2004 to Ishikawajima-Harima Heavy Industries, Ltd.



Basic Structure of a 10 kWh Class Flywheel

The Trend in Flywheel Units

Flywheel power storage systems have put to practical use to use mechanical bearings and heavier metals, for example, iron. Recently I have found on the Internet that an increasing number of corporations, including venture capital corporations, are commercializing flywheel units, primarily for uninterruptible power systems (UPSs) against lightning and other instantaneous power failures. Most of their

flywheel units are made compact because the flywheel can rotate at a high speed. Power loss is cut by reducing the load on the bearings. It seems that this type of flywheel equipment will be increasing in the market. Actually, many of them are delivered to semiconductor plants and data centers both in Japan and overseas.

ISTEK and five member companies are developing the ultimate system of this type—a superconducting flywheel power storage system—where the flywheel unit hovers in a vacuum and rotates at a high speed. The mechanism allows the power storage system to be compact and minimize power loss.

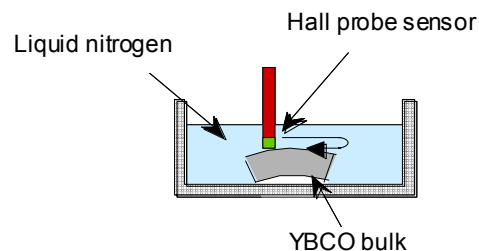
I would like to explain the difference in power loss between existing power storage systems and our superconducting flywheel power storage system. Existing power storage systems rotating at the highest speeds cease rotating in between several minutes and dozens of minutes when they are turned off, whereas our superconducting flywheel power storage system will continue to rotate for between several hours and dozens of hours because of inertial force and extremely small resistance.

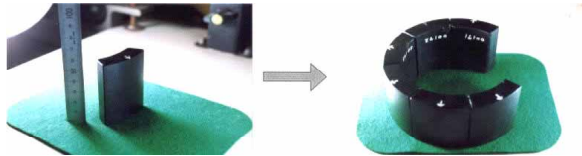
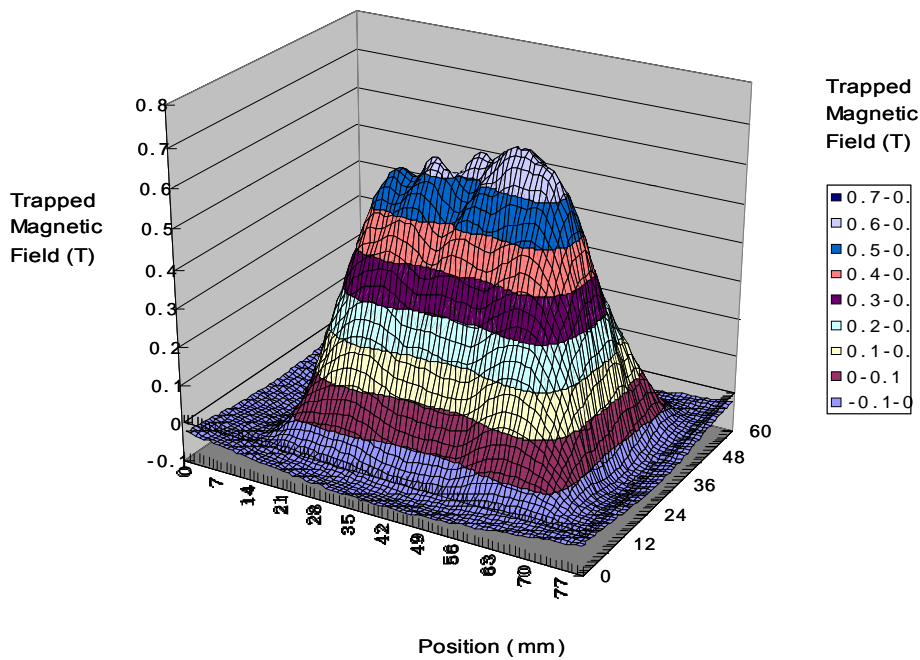
Nowadays we are engaged in two challenging subjects—the developing a bearing that controls high speed rotation and developing a maximum (300 f³)-class superconducting bearing, for the first time in the world.

All of the researchers are well aware of the significance of the development projects. Our efforts are unabated. (Mitsuru Tomita, Supervisory Researcher, Planning and Management Department, SRL/ISTEK)

Present Status of Bulk Superconductors for Bearings

We are engaged in the producing and evaluating YBCO bulk superconductors in a special form. These bulk superconductors are applicable to radial superconducting magnetic bearings for 10 kWh class flywheel power storage systems. The radial superconducting magnetic bearing has a structure of two different overlapping cylinders centering on a common axis. The outer cylinder has a rotor in the permanent magnet circuit, while the inner cylinder has a stator consisting of bulk superconductors. Each bulk superconductor has a Japanese roof tile shape—like a piece of a cylinder (123.2 mm outer diameter, 93.2 mm inner diameter, 60 mm height) divided into 8 parts in circumferential directions. The c axis of the roof tile bulk superconductor is directed perpendicular to the convex surface, which faces the permanent magnet circuit rotor.





Individual bulk superconductors are vacuum-impregnated with epoxy resin so as to prevent changes in aging, to enhance mechanical characteristics, and to improve reliability for long time use.

We measured the trapped magnetic field distribution of the bulk superconductors with a Japanese roof tile shape for bearings at liquid nitrogen temperature in order to evaluate the performance and soundness of these bulks. We measured the trapped magnetic field distributions above the convex surface of several bulks by scanning Hall probe sensor in a two-dimension direction. As a result, the peak trapped field value ranged from 0.4 to 0.7 T with nearly single domain. The maximum levitation force of the superconducting magnetic bearing module consist of 8 bulks was 2.124 N at liquid nitrogen temperature. (Kohji Matsunaga, Division III, SRL/ISTEC)

Current Situation of LTS Generator Development

Ken-ichi Nishijima, Manager, Generator Technology Department, Engineering Research Association for Superconductive Generation Equipment and Materials

A 70 MW class superconducting model generator has been developed by Super-GM from 1988 to 1999 in a national project on "applications of superconductive technology to electric power apparatuses", which was commissioned by NEDO as part of New Sunshine Program of AIST, MITI. After the mentioned project, Super-GM has started the following project, which is scheduled from 2000

to 2003 because the developed superconducting generator had cost problem compared to the conventional generators.

In this current project, the key technologies for larger-capacity and more-compact machine shall be developed. The major purpose of the development is cost reduction, which shall be achieved by more-compact and larger-capacity machines. For the more-compact machine, the stator and superconducting field winding current density shall be increased by 50% and then the generator size shall be reduced to 80% compared to the developed level. For the larger-capacity machine, 15,000A class armature current, 6,000A class field current and a 1,100mm rotor outer diameter shall be developed targeting 600MW class generator.

In the first year of the project, fundamental designs for the more-compact and larger-capacity machines has been carried out. In the next three years, detailed various analysis, and design and test for various element models are scheduled.

Current Status of HTS Motor Development

Tsutomu Hoshino, Associate Professor, Department of Electrical Engineering, Graduate School of Engineering, Kyoto University

The development of HTS (high temperature superconductivity) motors began around 1993. There are two types of HTS motors; one is a synchronous motor that has a superconducting field winding while the other is a solid core type motor that uses bulk materials as magnetic materials.

Since an induction motor has inevitable secondary copper loss when torque is generated, the generation of heat at the secondary conductor will become a major problem.

The motor using bulk materials is on a laboratory scale. A permanent magnetic type motor¹⁾ magnetized on the superconductor has a major problem that must be solved before practical application—how to reduce flux creep in the superconductor. A reluctance machine is reported as having improved in salient-pole characteristics²⁾.

Research of a hysteresis motor³⁾ using complete diamagnetism has been reported.

Since the field windings of the motor consist of superconducting coils, large electromotive force is available, which contributes to producing a compact size motor. The following types of dc motors are being researched; direct current homopolar motor for ship propulsion⁴⁾; direct current commutator motor⁵⁾; prototype synchronous motor which are two type such as rotating-armature type motor⁶⁾; and rotating-field type motor⁷⁾. Rotating-armature type motors are selected for compact motors.

Under the Superconductivity Partnership Initiative (SPI) started by the US Department of Energy (DOE) since 1988, Reliance Electric has been promoting the demonstration of a 1000 horse-power motor⁸⁾. In addition, the Republic of Korea has selected the motor as one of its 21st Century Projects and is working on the development of a 1 MW motor.

References

- 1) Z. Szuecs, *et al.* : Proceedings of ICEC16/ICMC, Part 2, pp. 945-948 (1996.5)
- 2) Yasuaki Ikeda, *et al.* : Japanese Electro-Technical Committee, Superconductivity Application Power Equipment Research Committee, ASC-96-13, pp.111-120 (1996.1)
- 3) P. Tixador, *et al.*: IEEE Transactions on Applied Superconductivity, Vol. AS-7, No. 2, pp. 896-899 (1997.6)
- 4) D. W. Hazelton, *et al.*: IEEE Transactions on Applied Superconductivity, Vol. AS-7, No. 2, pp. 664-667 (1997.6)
- 5) E. Spooner, *et al.*: IEE Proceedings-Electric Power Applications, Vol. 141, No. 3, pp. 135 -143 (1994.5)
- 6) R. Mikkonen, *et al.*: IEEE Transactions on Magnetics, Vol. 32, No. 4, pp. 2377-2380 (1996.7)
- 7) J. P. Voccio, *et al.*: Preprint of CEC/ICMC 1995, TU-S1-3 (1995)
- 8) http://www.reliance.com/news/press_releasespress_7_16_01.html

Superconductivity Related Research and Development Program in the Republic of Korea—Korea's KMOST Promotes New DAPAS Program (\$100 million)—

Superconductivity related research and development in Korea is bearing fruit under two programs; one is the Korean Superconducting Tokamak Apparatus (KSTAR) Program, which is being carried out by the Korean Basic Science Institute (KBSI) and the Korean Advanced Institute of Science and Technology (KAIST), both of which are under the Korean Ministry of Commerce, Industry, and Energy); the other is the DAPAS Program, which is being carried out

by the Center of Application Superconductivity Technology (CAST), which was formed by the Korean Ministry of Science and Technology (KMOST).

There is also another circle promoting superconductivity related research and development in Korea in cooperation among the government research institutes, universities, and companies in the private sector. These include Seoul National University (SNU), Ensei University, Kohsen University; Korean Atomic Energy Research Institute (KAERI), Korean Electric Research Institute (KERI), Korean Optical Technology Institute (KOPTI), Korean Electric Power Research Institute of Korean Electric Power Corporation (KEPCO/KERI)), and other government-owned research institutes; and Samsung Advanced Institute of Technology (SAIT), Cryogenic Vacuum Engineering (CVE), and other small- and large-sized enterprises in the private sector.

The KSTAR Program, under KBSI, has organized the Nuclear Fusion Research and Development Organization to supervise the entire program and its progress. According to the KSTAR Program, whose total budget figure is 318 billion Won as defined by 2001, R&D began in the end of 1995 and aims to operate the full superconducting tokamak apparatus (main radius: 1.8 m, plasma central magnetic field: 3.5T, plasma current: 2MA) by the year 2002, which will be three years behind schedule, and after first plasma the operation will last about 15 years, said by Dr. Jung-Hoon HAN, responsible person for KSTAR project.

The research and development of KSTAR is unique to achieve efficiency; the nuclear reactor design is carried out in joint development with the United States; superconducting (Nb₃Sn) wire rods are purchased from IGC Corporation of the United States and Mitsubishi Electric of Japan as intermediate products; superconducting magnet element testing is commissioned to the Superconductivity Testing Laboratory (SSTF) of Samsung SAIT.

The DAPAS (Dream of Advanced Power System by Applied Superconductivity Technologies) Program plans to invest \$100 million (130 billion Won) in a 10 year period. The program is being promoted by CAST, which is constructed in the premises of KERI. The DAPAS Program is one of Korea's 21st Century Frontier Research and Development Programs from a total of 10 programs. The budget is some 2.5 times larger than the annual budget of approx. \$4 million, which was the performance for fiscal 1997, spent by KMOST. The DAPAS Program consists of three fields and 9 R&D subjects, namely superconducting power equipment (ground cable, transformer, current limiter, motor); superconductive digital device (ALU: arithmetic-logic unit); and superconductive basic technologies (HTS silver sheath wire rod, HTS forced cooling conductor, low temperature technology, power system application technology). Except for the ALU, all R&D programs target high temperature superconducting materials. More specifically, the Program comprises the first period (element technology development), the second period (quasi-commercial prototype machine development), and the third period (demonstration test and commercialization technology development). Goals are set for each period.

According to President Kang-Sik Ryu of CAST who is responsible for the DAPAS Program, the program started independently from the past superconductivity R&D programs in Korea. The operating method is based on international cooperation. Four foreign institutions, including Nexans and ASC, have already offered CAST a joint R&D program. When this open operating method

succeeds, effects will reach 100 times larger than the amount invested. The DAPAS Program includes neither the Superconducting Magnetic Energy Storage (SMES) nor the research and development of a high frequency filter, which are commissioned to KERI, Seoul University (EESRI), and Korea Electronic Telecommunication Research Institute (KETRI), and other existing research and development institutions.

The superconductivity research and development programs in Korea are characterized as (1) having established an R&D system in close cooperation among the administrative, academic, and industrial circles; (2) having adopted an efficient R&D promotion method, including selections of young experts, purchases of intermediate materials and components from overseas, import of technologies from overseas, and international joint research and development programs, to supplement insufficient researchers (approx. 250 personnel in 1997); (3) taking part in international R&D programs as follows: the Korean Institute of Superconductivity and Cryogeny (KIASC), established in 1998, and the Cryogenic Association of Japan (CAJ) have begun bilateral cooperation : the Korean Research Institute of Standards and Science (KRISS) hosted an IEC/TC90 (Superconductivity) International Conference of International Electrotechnical Commission (IEC) in the autumn of 2001: Korea joined the Next Generation Intellectual Manufacturing System (IMS) in 2000, which was proposed by Japan. (Yasuzo Tanaka, Editor)

Superconductivity Related Research and Development Programs in EU—GROWTH and Other FP5 (2.5 billion yen) Are Underway—

The European Union (EU), consisting of 15 member nations, made a historical step forward by adopting the Euro currency in January 2002, which will circulate in 12 member nations. At present the EU has no independent superconductivity research and development program, but European Commission, the EU administrative agency, has been promoting superconductivity research and development programs by organizing and fundraising subsidies from a large-scale plan formulated by the Research and Technology Division (RTD) and energy division under the Fifth Framework Plan (FP5: 1998-2002), subsidies from member nations, funds from corporations in the private sector, and international cooperation. The EU's superconductivity research and development projects are within the framework of the GROWTH Plan, EESD Plan, and other large-scale plans. According to the result of a study commissioned to JETRO (Japan External Trade Organization) by CORDIS (<http://www.cordis.lu>) and International Superconductivity Technology Center (ISTEC), the number of EU's ongoing superconductivity related research and development projects amounts to about 10 and their annual budget reaches 23 million Euros (about 2.5 billion yen).

The EU's superconductivity related projects are featured as (1) RTD accounts for some 18% of the FP5 annual

FP5 Superconductivity Related Research and Development Projects in EU

Program name	Project name	Representing agency	Period	Budget M Euro	Subsidy rate %	Description
FP5/GROWTH	Q-SECRETS	Twente Univ. (NETHERLAND)	2000.07- 2003.06	2.39	59	SC power system
FP5/EESD	ACROPOLIS	FZK (GERMANY)	2000.10- 2003.09	5.15	54	AC loss reduction of Bi wire rod
FP5/HUMAN POTENTIAL		SEA (NORWAY)				SC coil
FP5/HUMAN POTENTIAL	JUELICH NEUTRONFOR	FZJ (GERMANY)	2001.11- 2004.03	0.7	100	Neutron research base
FP5/GROWTH	OPTIMISE	NST (DENMARK)	2000.01- 2002.12	5.81	53	PIT tape development HTS MRI development
FP4/BRITE/ EURAM3	SCENET- POWER	CNdR (ITALY)	Applied for postponement			EU research and energy technology network
	SUITABLE	Functional Material Center (GERMANY)	2000.09- 2003.08	1.4		Development and demonstration of alternative current oxide tape
	BIG-POWA	Pirelli (ITALY)	2000.03- 2003.02	3.86		Development and demonstration of Bi-2223 conductor powder
	READY	OI-PLC (UK)	1998.10- 2002.10	2		Development of alternative current YBCO tape, demonstration of a 100 kVA transformer
	BYFAULT	Schneider Electronic Engineering (FRANCE)	1998.07- 2002.06	1.86		Manufacture of a RE conductor for 17 MVA, 3-phase current limiters

budget(27 million Euros), and approx. 0.15% of which is appropriated to superconductivity related projects; (2) the subsidy rate to universities reaches 100% while the subsidy rate to corporations in the private sector are 50%; (3) superconductivity R&D is centered on the Ministry of German Federation of Education and Research (BMBF) in Germany. The German Government subsidizes an annual budget of 27.6 million marks (0.7% of the total budget or equivalent to 1.66 billion yen) through the VDI Technology Center. Meanwhile, Britain's voluntary supplementary budget is provided by the Engineering and Physical Science Research Commission (EPSCR) only, which subsidizes 255,000 pound (approx. 50 million yen); (4) FP5 GROWTH Plan recommends international joint development programs through the Intellectual Manufacturing System (IMS) within the limit up to 0.5% of the total budget; (5) the research and development is centered on the applied technology development of energy technology rather than telecommunication and network technologies, for example, represented by SCENET.

One of the concrete results in the EU projects is found in the implementation of an oxide superconducting cable in Copenhagen, Denmark in 2001, which was for the first time in EU, under a joint development by NKT Group and Pirelli Corporation. The elemental technology has been developed with a financial subsidy from Q-SECRETS and OPTIMISE of FP5 GROWTH (8.2 million Euros in total) and while the applied technology has been developed with a financial subsidy from DanishNXT, Denmark Energy Agency, and Eltra and Elkraft power companies (approx. 60 million yen).

The FP5 GROWTH subsidy has brought about ripple effects. For example, under assistance from the German Federation of Education and Research (BMBF), Siemens successfully developed a 400 kWh class superconducting motor in 2001 for the first time in the world. Some of the achievements are found at <http://www.nst.com>. (Yasuzo Tanaka, Editor)

Report of 2001 Japan-EU Workshop on Superconductivity

Kazumasa Togano, Director, Fundamental Materials Research Center, National Institute for Materials Science

From December 12 to 14, 2001, a workshop on superconductivity was held at National Institute for Materials Science in Tsukuba, Ibaraki Prefecture by Japan and the EC. The Japan-EC joint workshop on superconductivity was held for the first time although periodical joint workshops between Japan and the United States have been held over the past years.

A talk between the International Section of the former Science and Technology Agency and the European Union (EU) Research Bureau resulted in holding the 2001 Japan-EC joint workshop in order to promote research and development programs on superconducting materials in mutual cooperation and in an efficient manner. The Material Promotion Office of the Ministry of Education, Science, and Technology in Japan played the role of a liaison office, while the National Institute for Materials Science played the secretariat role. Meanwhile, Dr. Ageladarakis at the European Commission Headquarters played the

secretariat role for the EU side and Professor Marezio of Parma (Italy) intermediated researchers in the EU region.

Twenty researchers from the European side participated in the December Japan-EC joint workshop as planned despite negative effects from the September 11 Terrorist Attacks being expected. Major participants from the EC side include Deutcher (Tel Aviv), Evett (Cambridge), Freyhardt (Goettingen), Flukiger (Geneva), and Weber (Vienna). What was noteworthy were participants from Pirelli, Nexan, Siemens, NST, and other leading corporations.

The Japanese side had over 80 participants (including 26 speakers), including Professor Akimitsu, who found MgB_2 and drew worldwide attention, and other first-string researchers and professors. The Japanese secretariat is grateful for their participation.

A roundtable discussion was held at the end of the joint workshop to discuss possible future cooperation between Japan and Europe, but some issues remained unsolved because of their different research and development systems. Superconductivity researchers in Europe are centered on SCENET, which has strong leadership.

Japan does not have a single ruling organization equivalent to SCENET; superconductivity research and development projects in Japan are led by the Ministry of Education, Science and Technology and by the Ministry of Economy, Trade and Industry. European participants had trouble understanding these administrative divisions. It seems that the Japanese side needs some arrangements to consolidate the R&D systems, leaving the question which system is better.

SRL Director General Awards for Autumn 2001

ISTEC and SRL, led by Director General, Shoji Tanaka, hold awards ceremonies in the spring and autumn every year. The awards ceremony for autumn 2001 was held on November 13. Introduced below are the award winners.

Director General Award (three themes):

- Improvement of superconducting properties in sintered MgB_2 with Ti doping: Yong Zhao, Takato Machi, Daxiang Huang
- Crystal growth of MgB_2 : Sergey Lee
- Operation of a sigma-delta AD converter with sampling frequency of GHz: Haruhiro Hasegawa, Tatsunori Hashimoto (Mitsuhiro Anju, General Affairs Department, ISTEC)

Forefront of Science and Research

65th Meeting on the Cryogenics and Superconductivity in Autumn 2001

This meeting was held from November 23 through 25, 2001 at Fukui Institute of Technology, located in Fukui City, Fukui Prefecture, Japan. A local newspaper reported that in the meeting a Korea-Japan joint workshop was held with Korean societies of applied superconductivity-cryogenic engineering and that a total of 500 people participated in the meeting. On the 26 of November, a

special session in the joint workshop was held at another venue. Since the space is limited, this report focuses on materials, especially Y-based coated conductors. Please note that this report covers only a part of the meeting.

A session on Y-system materials was held all the day on November 23. Compared with past meetings, this time drew much attention from researchers and ordinary people as well, which may indicate stronger prospects for practical applications. Applications of Y-based materials include, first of all, coated conductors. Concerning PLD film on IBAD tape, the formation of a 1 m/h intermediate layer formation in the length of several tenth meters was presented, where the $Gd_2Zr_2O_7$ of pyrochlore structure was applied for intermediate layer. In addition, PLD deposition speed of YBCO reached 4 m/h and J_c was over 1.2 MA/cm². Although long time operation of an excimer laser is not yet possible, a project goal of making a 100-meter long wire is likely to be accomplished easily by Fujikura group. Sumitomo Electric Industries has developed the Reverse (R) ISD method: an improved ISD version. This new method allows us to compensate inclinations of c axis, which has been a major problem, within 2 to 3 degrees by reversing the substrate angle during deposition. The Ho-123 is formed on the substrate, and as the result, the J_c increased to approximately twice the size of those of existing substrates. Concerning SOE substrates, CeO₂ cap layer formation and crystallization of antecedents were announced in anticipation of making 100-meter long substrates and the BaF₂ ex-situ method (Furukawa Electric Co.) The J_c of 0.45 MA/cm² was obtained by using 0.17 MA/cm² and a new BaSnO₃ intermediate layer through planarization of the SOE substrate (Kyoto University). Concerning the TFA-MOD method that offers superior characteristics in spite of a low-cost non-vacuum process, an SRL group reported reproductions of J_c beyond 10 MA/cm², by using a YSZ substrate with the CeO₂ buffer layer. The SRL group also reported multiple-coating of precursor led to attaining 3.1 MA/cm² for the film of a 1 micrometer thick on oxide crystalline substrate. This means attaining nearly 300A of J_c on a 1-cm wide substrate, which is a very high value. The future problem is how to attain such a high value on metal bases. LPE is another non-vacuum process that SRL has developed. A J_c beyond MA/cm² was attained when the processing temperature was lowered down to 800 degrees Celsius, which opened the door to substantial continuous processing for coated conductors.

Large area thin film formation is important for applications of Y-based materials, including RF applications and current limiter. A research group at Nagoya University and Yamagata University conducted large film formation by means of scanning target of Sm-123, to measure the surface resistance. For SN type current limiter applications, Sumitomo Electric Industries coated Ho-123 on CeO₂ buffered sapphire with a 3-inch diameter to examine the distribution of the J_c characteristics, which indicated 2 MA/cm² on the average. This is a fairly high value. In addition, Central Research Institute of Electric Power Industry(CRIEPI), National Institute of Advanced Industrial Science and Technology, and Toshiba obtained basic data including J_c distributions by using a large area film which is formed in the coating thermal decomposition method, indicating possible application to current limiters.

Also, concerning Y-based materials, a number of results were presented, including J_c (Kyushu University), AC loss

(Yokokama National University), mechanical characteristics, and other characteristics.

MgB₂ is a newly discovered materials in 2001, and its wire processing is developed at the National Institute for Material Science. In particular, it was interesting to hear that a wire of high J_c was produced only by pressing without thermal treatments. There were several presentations by other groups on this material: selection of sheath materials, post-thermal treatment, and additive effects (Tokai University), and electromagnetic characteristics (Kyushu Institute of Technology).

Finally, let me introduce topics on refrigeration technology. Josephson mixers and particle detectors need refrigeration down to 1 K or below, in order to deter noise and improve resolution. This temperature is out of the ordinary liquid ⁴He temperature range. The temperature is usually created by using ³He or a dilution refrigerator. The necessity of installing them in satellites and other compact machines led to the successful development of a solid refrigerator that reaches 0.1K in multistage adiabatic demagnetization (NASA). Driving an existing compact refrigerator by using ³He realized a low temperature down to 0.7K. This area has already been studied by Iwatani and Sumitomo Heavy Industries which circulated corresponding product catalogs at the meeting. Such low temperature has been limited to small groups of low temperature physics, but the recent advance in refrigerator is expected to contribute to wide applications as well as fundamental sciences. (Izumi Hirabayashi, Director, Div. V, SRL/ISTEC)

Topics on Applied Superconductivity Research Symposium

This symposium, hosted by the Cryogenic Association of Japan (CAJ), was held on October 12, 2001 at Chiba Institute of Technology located in Tsudanuma, Chiba Prefecture, Japan. The symposium focused on the theme of "Research and Development of Superconducting Digital Circuits" and four keynote speeches were presented before entering the general discussion.

Dr. Fujimaki (Nagoya University) explained three obstacles that the current semiconductor integrated circuit technology is expected to face around the year 2005, namely complication of circuit design, increase of power consumption, and wiring delay. At the same time, however, he introduced three possible key technologies where superconducting circuits are applied to overcome the three obstacles, namely the AD converter, the high-end network router, and the network server.

Dr. Yorozu (NEC Basic Research Laboratories) introduced an Nb junction standard fabrication process foundry (funded by science promotion coordination fund project of the Ministry of Education, Science, and Technology). He also introduced a cell-based design method and reported the design and operation (low speed) results of a 2 x 2 packet switch, as an example of the cell-based designed circuit.

Dr. Nagasawa (SRL/ISTEC) reported the design and operation (low speed) results of a superconducting latch/SFQ hybrid RAM.

Dr. Yoshikawa (Yokohama National University) described the Cryo-CMOS memory circuits which achieved high-

speed operation by using Josephson junction based sense circuits.

The general discussion focused on "What technology is the most important for practical application of superconducting digital circuits by around the year 2010?" Most of the participants agreed that the answer is low-temperature and high-speed packaging technology.

(Kazunori Miyahara, Div. VII, SRL/ISTEC)

Way to the Quantum Computer

What is awaiting us at the forefront of the ongoing development of existing supercomputer architecture may be the development of a superconducting quantum computer based on a completely new computation algorithm.

The computation speed of the fastest computer at the beginning of the 21st century recorded tera-flops (several tera times of floating point arithmetic operation per second). According to an article in the Nihon Keizai Shimbun published on November 12, 2001, IBM and Lawrence Livermore Laboratory announced a joint project that aims to develop a supercomputer of 200 tera-flops arithmetic operation by the year 2005, as part of the "Blue Jeans" program. I wonder we could use a peta-flops computer (1 peta is 1,000 teras) by the year around 2010.

The ongoing development of supercomputers is based on the architecture (design concept) of the von Neumann computer to which the CMOS (complementary metal-oxide semiconductor) is mainly applied. Past developments managed to process large volumes of data through miniaturization and very large scale integration (VLSI) of electronic devices. However, the resulting device, namely the computer, has two major problems. One problem is economical. As indicated in a report prepared by T. Starling at NASA Jet Propulsion Laboratory, the electronic device (CPU) costs no less than US\$40 per 1 mega-flop and emits much heat, leading to costly operation. The other problem is technical. The device cannot calculate certain subjects within a useful time even when the computation speed is raised. According to Starling and a researcher at the National Institute of Science and Technology Policy, the Ministry of Education, Science, and Technology, the tera-flops computer naturally takes a lot of time to calculate such subjects. Even the peta-flops computer will take a lot of time to calculate such subjects. These subjects include forecasts of climate fluctuations, design of a practical nuclear fusion reactor, three-dimensional analysis of protein and overcoming obstinate diseases, ecological control of the global environment, diagnosis of nuclear weapon degradation, economic forecasts, development of a quantum new element, analysis of cryptic telecommunications, estimation of a Galaxy model, and many other scientific subjects.

Jaw-Shen Tsai (NEC Basic Research Institute) reported that those scientific subjects would be calculated only by the quantum computer (where solid elements are applied). In cooperation with Yasunobu Nakamura and Y.A. Pashkin, Jaw-Shen Tsai succeeded in electrical control of overlapping quantum bits (in coherent state) by applying superconducting devices (solid elements) (Nature, Vol.

398, 29 April, pp.786-788). The successful result is epoch-making in terms of using solid elements, taking a large step toward practical application of a quantum computer. Their research is underway to develop a 100 quantum bits circuit by the year 2010.

(Yasuzo Tanaka, Editor)

Superconductivity by Field Effect Doping

Takehiko Ishiguro, Professor, Graduate School of Science, Kyoto University

The year 2000-2001 saw a lot of epoch-making findings in superconductivity research as featured in the science magazines "Science" and "Nature." In the 2000, Bell Laboratories announced a successful finding of new superconductivity in C_{60} crystals doped by the electric field effect ¹⁾. The announcement was just the beginning of a series of other findings, suggesting a new frontier in the research and development of superconductivity technology. Superconductivity in organic molecular crystals, such as anthracene, were reported ²⁾. Further, a report appeared in September, 2001, claimed the transition temperature of 117K in C_{60} crystals with expanded lattice by introducing $CHBr_3$ molecules ³⁾. The discovery of superconductivity in oxides with ladder structure by the electric field doping was also reported ⁴⁾.

Naturally, many superconductivity researchers around the world are tracing these findings and attempting to ensue the reported results. A single research laboratory alone, however, can make an insulation film of the high withstanding voltage and other laboratories or researchers cannot reproduce or examine the superconducting phenomena reported.

At the beginning, the focus centered on whether doped carriers localize on the interface sheet of molecular film or not. A recent theoretical calculation ⁵⁾ has pointed out that charged carriers may be unevenly distributed on the first layer alone under the condition where Coulomb interaction is effective on the tight-binding band calculation. Although the state density in this area can be raised, it also accompanies a modification on the electronic structure. It is unthinkable that the naïve arguments for a ridged band can be applied to explain the research results as they are. Provided that reported experimental results are correct, it means that basic physical problems have been involved in the phenomena.

If a sheet of molecule layer works as superconductor, it is a genuine two-dimensional superconductor; the similar sheet superconductor is known for the high temperature superconductor $YBa_2Cu_3O_x$ showing a broad transition behavior. Compared with this, the transition of the reported superconductor with the transition temperature of 117K was characterized by a well-shaped sharp transition behavior. Although the coherence length was reported, the data on the transition characteristics under magnetic fields were not presented. Fluctuations, enhanced by the magnetic field, were supposed to be more prominent than those in the ordinary second kind superconductor, making it difficult to determine the transition point. We would like to have a report on the transition characteristic in the magnetic field.

To obtain such a superconductor, it is necessary to apply the electric field as high as nearly 10^8 V/cm on Al_2O_3 insulation films. It seems that using ferroelectric film will

lead to lower the electric field in the future. However, for ordinary materials, the electric field means to extremely high withstanding field. To lower the electric voltage to the level of 100V or so, the film thickness must be set to the level of 10 nm. To this end, the substrate flatness must satisfy that of one molecular level. This could be realized for a cleaved crystal or an epitaxial film. For mechanical polishing, well-trained high-level technique is required. To reproduce the experimental results, you need to prepare a film capacitor that can sustain a sufficient withstanding electric field.

References

- 1) J. H. Schoen, Ch. Kloc, R. C. Haddon and B. Batlogg: Science 288 (2000) 656.
- 2) J. H. Schoen, Ch. Kloc and B. Batlogg, Nature 406 (2000) 702.
- 3) J. H. Schoen, Ch. Kloc and B. Batlogg, Science 293 (2001) 2432
- 4) J. H. Schoen et al. Science 293 (2001) 2430.
- 5) S. Wehrli, D. Poilblanc and T. M. Rice Cond-mat/0106433.

Development of a Conjunction Technology Led to Successful Development of an Ultra Strong Bulk Superconducting Magnet

On Tuesday, December 18, 2001, International Superconductivity Technology Center (President: Hiroshi Araki), Superconductivity Research Laboratory (Director General: Shoji Tanaka), Morioka Laboratory, Iwate Industrial Research Institute (Director General: Takatoshi Kohno), and Iwate Technology Promotion Center (President: Takehiko Kaizuma) gathered together in Iwate Prefectural Government Office to announce that a technology of uniting 4-cm diameter bulk high-temperature superconductors had been successfully developed. The announcement indicated that a long time problem was overcome, opening the door to making large bulk superconductors.

In recent years, bulk high temperature superconductors have been highlighted for the application of ultra strong superconductor bulk magnets of permanent magnet type (The magnet field of permanent magnets could be 1 tesla at most while that of superconducting bulks could be 10 teslas or more). When bulk superconductor magnets are used in a relatively large space, large bulk superconductors will be essential. For example, when using bulk superconductor magnets for magnetic levitation trains, a bulk superconductor of a diameter of 15-cm or larger will be necessary.

At present, the progress of process technology allows you to make a large bulk superconductor of up to 10-cm diameter by using a Y-Ba-Cu-O superconductor. Although there is a case where a bulk superconductor of more than 10-cm diameter was made, its characteristics were low due to weak binding power deriving from local segregation of impurities in the superconductor.

Many research institutes around the world are trying to develop a technology of uniting multiple superconductors. Many have already been reported, indicating successful developments of samples of a several mm diameter. However, the success at the Superconductivity Research Laboratory Morioka Branch Office is different from these samples. The office succeeded in uniting bulk superconductors of 4-cm diameter by controlling the direction of bulk superconductor crystals, which was done

for the first time in the world.

The success at the Morioka Branch Office suggests that an ultra strong magnet with 10-tesla or more could be developed. Many applications using such reinforced magnet fields are now expected to flourish, including MRI (Magnetic Resonance Imaging), magnet separation equipment for resource collection and waste water purification, excitation equipment, and strong magnetic levitation equipment.

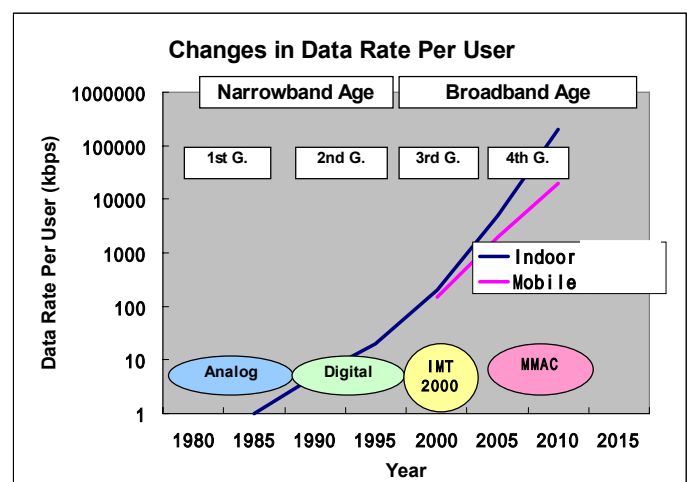
This research has been commissioned to ISTE by NEDO (New Energy and Industrial Technology Development Organization). For more detailed information, visit the ISTE website at http://www.istec.or.jp/SRL_homepage/SRLmain_1op-l.html.

(Mitsuhiro Anju, General Affairs Dept., ISTE)

One-Step Advanced Superconducting A-D Converter: SRL Made a Prototype for 4th Generation Mobile Communications

ISTEC (President: Hiroshi Araki) announced a successful integration of interface circuitry for an AD conversion module, digital filter circuitry, and semiconductor circuitry, on a substrate by combining element technologies already developed. The announcement of developing the superconducting A-D conversion technology (called "sigma-delta type A-D converter") was made at the Electronics Society Conference of IEICE (Institute of Electronics, Information and Communication Engineers) held in September, 2001 at Chofu, Tokyo. The same announcement followed at an ISS2001 conference (September, 2001 at Kobe) and in the Nikkei MicroDevice magazine (December 2001 issue), and at a Superconducting Communications Conference held in December 2001 at the University of Tokyo.

At present, the 3rd generation systems of cellular phones, PHS, and other mobile communications, represented by IMT-2000, include the transmission of images in addition to sound transmission. The 4th generation system and after are expected to form a variety of information networks including animated pictures. According to a "Telecommunications White Paper" prepared by the Ministry of Public Management, Home Affairs, Posts and Telecommunications, the market size of cellular phones



and PHS alone is estimated to reach 4.5 trillion yen in fiscal 2005.

According to a technical forecast by the Ministry of Public Management, Home Affairs, Posts and Telecommunications, the data transmission speed per user will reach 50 to 100 Mbps by the year 2010. Accordingly, a wireless base station will have to handle several hundred MHz (broadband). However, such broadband must clear a number of bottlenecks, including successful developments of a low-noise amplifier, an A-D convertor, and digital signal processing circuit technology. In particular, the focus is centered on the successful development of superconducting A-D conversion technology, which can realize higher speed, higher efficiency, and lower consumption of power.

Past research and development of a superconducting A-D convertor have remained at the levels of single development of element circuits and of combinations of operation technologies. These include, for example, the development of a modulator circuit that converts analog signals into digital signals; the development of a decimation filter circuit that levels digital signals and removes quantized noise; and the development of an interface circuit that converts ultra-high speed slight amplitudes in low temperature into low-speed small amplitudes at room temperature. However, practical-use equipment must be compact and light-weighted to control interference between circuits and to integrate the circuits, besides low consumption of power.

The point of this successful technological development lies in the demonstration of circuit integration technology for practical application. More specifically, the center of the demonstration was the successful operation of the superconducting A-D converter of 10 MHz analog frequency bandwidth, 5 bits (number of bits), and 28 micro W power consumption, where niobium junction integrated circuit in the single flux quantum (SFQ) system is applied.

More advanced telecommunication technologies, such as software radio communications, are expected to emerge in the near future. Thus, developments of high-integration design technology, micro-processing technology, implementation technology, and measurement technology are indispensable to enjoy the benefits of a superconducting A-D convertor which targets 5 GHz central frequency bandwidth proximity, 100 MHz analog frequency bandwidth (indoor: 200 MHz), 12 bits (number of bits), and several mW power consumption.

(Yasuzo Tanaka, Editor, ISTECS)

Patent Information

-from December 2001 to February 2002-

Introduction of Patent Approved

We would like to introduce a patent, recently approved

"PRODUCTION OF OXIDE CRYSTAL AND APPARATUS FOR PRODUCING THE SAME" (Publication No. 1996-183693: applied in 1994)

This patent is related to a method for fabricating superconducting crystal of yttrium oxides and lanthanoid oxides.

To fabricate large single crystals of an oxide superconductor, the traveling speed of the crystal pull-up shaft must be controlled for a long time so as to keep the crystal growth surface in touch with the surface of a raw material melt prepared in a crucible.

Specifically, one of the important claims in this patent is that the traveling speed of the rotating pull-up shaft is estimated and controlled by prediction of descending speed of the surface of a raw material melt and the growth rate of the crystal, and the other is in a detecting method of the surface position of the raw material melt. This is a major patent in manufacturing large single crystals of an oxide superconductor.

For detailed information, visit the relevant homepage of the Intellectual Property Digital Library (IPDL) of the Patent Office of Japan.

Patent Information Retrieval Seminar Held

Moves for early examination of patent applications are on the way.

For example, the Patent Office of Japan has decided that the patent applications, applied after October 2001, must be filed a request for examination within three years from the filing date, while the US Patent Office has already moved to the publication system of unexamined applications.

Meanwhile, inventors are strongly required to make patent quality better than before.

Considering above background, ISTECS invited Mr. Katsuyoshi Fukuzawa, instruction adviser of the Tokyo Center of Intellectual Property Rights to SRL(Shinonome) on November 30, 2001.

He introduced us the information retrieval system on the Intellectual Property Digital Library (IPDL) of the Patent Office of Japan.

Especially, he gave a number of examples of retrieval methods and references for the superconductivity field and introduced how to retrieve patent gazette text, how to search with F/I/F terms, and other useful retrieval methods, besides how to directly access to the foreign patent retrieval systems of US and Europe from the homepage of the Patent Office of Japan.

This seminar drew the strong interest of those attending.

Published Unexamined Patents for the 3rd Quarter of Fiscal 2001

Introduced below are ISTECS's published unexamined patent applications from October to December 2001. For detailed information, visit the homepage of the Patent Office of Japan and check the patent database of the Intellectual

1) Publication No. 2001-308399: “
“SUPERCONDUCTING JOINT ELEMENT AND
MANUFACTURING METHOD THEREOF”:

The existing manufacturing method of Josephson junctions forms an insulating film or other ultra-thin barrier layer between the lower superconducting electrode layer and the upper superconducting electrode layer. This patent introduces a new method of the Josephson junction that can omit the formation process of a barrier layer, by using different kinds of oxide superconductors for the lower and the upper layer materials, for example YBCO film for the lower and NBCO film for the upper.

2) Publication No. 2001-342020:
“RARE EARTH OXIDE SUPERCONDUCTOR
MANUFACTURING METHOD”:

The purpose of this invention is to provide a method of manufacturing a rare earth oxide superconductor having a high density and a high strength. The existing method cannot prevent many empty holes in bulk oxide superconductors, which deteriorate their mechanical properties caused by the residual gases during heat treatment and the oxygen out-gases during heat decomposition. The new method of manufacturing an oxide superconductor can reduce these defects.

(Katsuo Nakazato, Director, Research and Development Div., SRL/ISTEC)

Standardization Activities

-On January
“Summary of the Results of the study on the Future Activities of the IEC/TC90 Superconductivity Committee”

The IEC/TC90 Superconductivity Committee, with Shigeki Saito (Senior Managing Director, International Superconductivity Technology Center) serving as its chairman, received a report on November 30 from the subcommittee set up to study its future activities. The subcommittee to study future activities, with Shirabe Akita (Central Research Institute of Electric Power Industry) as its chairman, consists of the representatives of twelve organizations that are major manufacturers of electrical materials/appliances and electric power as well representatives of bodies that take a neutral stance.

According to the report, the IEC/TC90 Superconductivity Committee deals with the duties of the secretariat country of the ninetieth Technical Committee (TC90) under the International Electrotechnical Commission (IEC). Since its inauguration in 1990, this IEC/TC90 Superconductivity Committee has been actively undertaking its activities. Already, the committee has made contributions not only to research and development on superconductivity but also to the progress of the superconductivity industry including legislation on seven International Standards (IS) and three Japanese Industrial Standards (JIS). However, to cope with the severe external environment nowadays, the significance of its continued activities concerning future strategies on

superconductivity standardization is keenly realized.
* Securing a common market adaptability in the field of superconductivity application
* Promotion of international standardization activities with IEC/TC90 playing the central role
* Unified facilitation of standardization activities and R&D projects

In response to the report, the chairman, Saito, stated: “As a committee to deal with what is called world superconductivity standardization activities, we should reconfirm our activities for the 21st century and devote ourselves to the three strategies of superconductivity, i.e. accurately grasping standardization and market needs, placing emphasis on international activities, and unification of the international activities with R&D projects. For this purpose, further positive participation of the companies in the superconductivity industry, their closer cooperation with related countries, and creation of strategic undertakings toward standardization of R&D projects are essential. I would like to ask all the members of the Superconductivity Committee for further understanding and cooperation on these matters so that these standardization activities may bring forth practical results.”

(Secretariat of the IEC/TC90 Superconductivity Committee)

-On February
The First Year of the Standard-related Competitions
In the 21st century, a patent litigation arose on a superconducting filter technology in the field of superconductivity telecommunication. On the assumption that a new superconductivity industry is to be born in the 21st century, this type of standard competition involving intellectual property rights will be unavoidable. Based on this concept, we may say that we are facing the very first year of standard-related competition. To cope with such changes in the standardization environment, activities to standardize superconducting products are in progress.

The market for MRI devices for medical treatment and NMR analysis devices, whose applications have already been settled, has developed into an over 200 billion yen market. However, there is no record that patent disputes or standard-related competition have arisen. As one reason for this, we may cite the fact that the far-reaching effects concerning the functions of these conventional, stand-alone superconducting products are limited. In other words, the above devices offer their advanced services only to single specific persons, customers and regions, and their introduction has never caused any ripple effect on global or social issues.

On the other hand, superconducting filters are indispensable to the IT society especially to the ever-advancing new telecommunication systems. In spite of the current market scale of superconducting filters being around 1 billion yen at best, the patent dispute issue referred to above occurred. We understand from this fact what a large social impact this device has. This event can be seen as a sign that the rise of the 21st century superconductivity industry may also be ranked as the significant beginning of the superconductivity standardization competition which is likely to subsequently take place.

In consideration of the above situation, the activities of the IEC/TC90 Superconductivity Committee involves the investigation of superconductivity standardization needs which came to be closely connected with intellectual

property rights including patent rights in FY 2000. Based on the standards for superconductivity terms and test methods as a result of the conventional standardization activities, activities are in progress toward construction of the general standards for superconducting products to cope with the new telecommunication systems on new environment-related systems, new medical care systems and new educational systems as well as the new lifeline systems on new energy systems, and new traffic/logistics systems which are indispensable to the 21st century. In order that the above purposes may be attained, Japan should first take the lead in establishing the compendium of the standards for superconducting products without being reconciled to the market development of the individual superconducting products or results of its single-handed development of superconductivity technology. Then, by making full use of its technological capacity and negotiation power on international technologies, it is necessary for Japan to control the environment of developmental competition between conventional de jure standards and new de facto standards. This standardization competition is considered as the very driving force essential to the creation of the superconductivity industry and its development.

(Yasuzo Tanaka, Director, Standardization Dept., ISTECS)



Published by International Superconductivity
Technology Center

5-34-3, Shimbashi, Minato-ku, Tokyo 105-0004
Japan

Tel +81-3-3431-4002 Fax +81-3-3431-4044

ISTEC home page: <http://www.istec.or.jp/indexE.html>



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