Superconductor Week

Commercialization · Markets · Products
Business Developments · R&D · Cryogenics

October 14, 2011 Vol. 25, No. 16

KEPCO Distribution-Voltage SC Cable System Energized

Korea Electric Power Corporation (KEPCO), LS Cable & System and American Superconductor Corporation (AMSC) have announced that a 500-meter distribution-voltage superconductor cable system has been energized at the I'cheon substation near Seoul, South Korea, in what will be a permanent installation. AMSC supplied the superconductor wire installed at the I'cheon substation.

The 22.9 kV alternating current (AC) cable system is capable of carrying approximately 50 MW of power. The cost of the installation was not disclosed.

"Because superconductor technology provides a reliable, cost-effective solution to rising electricity demands, we see it as a tremendous growth opportunity," said LS Cable & System President Jong-ho Son.

"Beginning with helping to fulfill KEPCO's vision and expanding into a global business, we plan to capitalize on superconductor technology to meet the growing power demands of Korea and the world."

Cable System Supplied through LS, AMSC Agreement

In 2010, LS Cable and AMSC entered into a large-scale commercial superconductor wire supply agreement (see *Superconductor Week*, Vol 24, No 19). AMSC recently made its initial wire shipment to LS Cable under the new agreement to allow it to begin qualification work for Korea's next superconductor cable projects.

AMSC declined to disclose the amount of wire it has shipped to LS Cable to date. KEPCO is planning a 1 km, 154 kV superconducting alternating current (AC) cable system and a 500 meter, 80 kV direct current (DC) cable system in the grid on South Korea's Jeju Island. ❍

NIST Creates Improved Quantum Ground State Micro-drum

Researchers with the National Institute of Standards and Technology (NIST) have attained the quantum ground state using a superconducting circuit containing a microscopic aluminum drum. The technique employed by researchers and the drum device may be employed in quantum computing, conducting tests of quantum theory, and advance the field of quantum acoustics.

"In order to reach the fundamental or quantum mechanical limitations of position measurement, it is desirable to remove all the thermal energy or noise from the key measurement element," stated Raymond Simmonds, Member of the NIST Quantum Devices Group. "Here, the micro-drum's motion was cooled to the ground-state, allowing a nearly quantum-limited measurement of its motion. In addition, preparing a definite state of a quantum system is necessary in order to use that system as a quantum information resource.

"The ground state is unique in that it represents the lowest energy state possible. The use of the next energy state above this level (by one quanta) allows the system to store one bit of quantum information. Reaching the quantum ground state, and the ability to stay there for long times, establishes the first challenge to fully manipulating the quantum states of the micro-drum."

Simmonds: Energy Lifetime at Mechanical Quantum State near 100 Microseconds

Simmonds added that the device held the promise to increase the energy lifetime of quantum information storage devices: "The energy lifetime for the mechanical quantum states should be near 100 microseconds. This time duration is at least 10 times longer than most other types of superconducting circuits that have demonstrated the storage of quantum information. Without time to perform quantum manipulations, it is impossible to create and control quantum states with any complexity, which is the goal of quantum acoustics.

"In addition, every computer needs a memory, including a quantum computer. The loss of energy leads to the loss of crucial information, which is extremely detrimental to building a high-performance device. In addition, harmonic oscillators represent another type of quantum system that can be used as a tool for the manipulation of quantum information."

Simmonds also said that the micro-drum represents the first step towards the manipulation of mechanical phonon states: "Quantum acoustics is based on the idea, in analogy with quantum optics, that individual phonon states can be prepared, controlled, and measured with quantum-level accuracies. Our new device represents the first long-lived mechanical quantum system to reach its ground state.

Superconductor Week

Superconductor Week (ISSN 0894-7635) is published 24 times a year by **Peregrine Communications**

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"This is a first step towards full preparation and manipulation of mechanical phonon states. The micro-drum is a quantum acoustical system that works nicely and has the right properties to do more in the future."

Simmonds said the need for zero energy loss was a major factor in working with a superconducting material: "It is important that both the electromagnetic and mechanical systems are isolated and do not lose energy, which leads to loss of quantum information. Superconductivity provides a way to store electromagnetic energy in the form of electrical currents and voltages with almost no energy loss. We used a dilution refrigerator to pre-cool the whole circuit, which included the mechanical drum, to below 20 mK."

Process Robust, Reproducible

Simmonds confirmed that the Quantum Devices Group used a flexible and reproducible process that should allow other researchers to diminish the vibrations of a mechanical object down to the quantum ground state: "The micro-fabrication process developed at NIST is robust and reproducible. It is relatively easy to perform, requiring only two metallic layers and one sacrificial layer. It will also allow the fabrication of many copies on a single chip, an important requirement for scaling up to larger and more complex systems."

The NIST experiments came close to stopping the beating motion of a microscopic drum composed of roughly 1 trillion atoms, putting its energy below a single quantum, or one unit of energy. While the drum beat at 11 million times per second, the range of motion this involved approached zero. In order to calm the motion of the drum, the NIST researchers created pressure via microwave radiation.

"The frequency of this radiation and energy content per photon is compatible with superconducting circuits that allow the control of electromagnetic energy in the form of electrical currents and voltages," said Simmonds. "In addition, this type of radiation is easy to supply to circuits through coaxial cables and is compatible with low temperature, cryogenic techniques required for precooling the system far into its superconducting state."

Although a team of researchers at the University of California, Santa Barbra (UCSB) was able to attain the quantum ground state last year, the NIST drum can beat longer and at a lower frequency. This allows it to store energy for up to 100 microseconds.

Other advantages of the NIST drum include a large amount of zero-point motion, less energy decay, strong coupling between motion and the electromagnetics, direct position measurement of the drum motion near the quantum limit, and simplicity of operation. The UCSB researchers that developed the earlier drum design collaborated with the NIST on the current device.

Further Improvements Underway at NIST

"Improvements are currently underway in our group at NIST in order to enhance the device performance, such as stronger coupling and reduced energy loss," said Simmonds. "Some of these improvements can be achieved through simple geometrical changes, while others will require a new construction with new materials. Although the devices we have already will allow us to perform more interesting experiments, currently underway, we always strive to improve our system performance."

The NIST quantum information program has been active for nearly 20 years, starting with the development of atomic clocks. NIST's Superconducting Quantum Information and Measurements Project has been active over the last 10 years in researching Josephson junction-based circuits for quantum information, as a part of NIST's overall mission to advance quantum information technologies and quantum-based measurement science. The new micro-drum mechanical system was developed as part of this

overall research program. ❍

Superconductor Week Speaks with W2AGZ's Paul Grant

Superconductor Week spoke recently with Paul Grant, Principal of W2AGZ Technologies, an energy consultancy based in San Jose, CA. From 1982 to 1989 Grant led the superconductivity effort at the IBM Almaden Research Center that solved the structure of YBCO. From 1993 to 2004, Grant was a Science Fellow at the Electric Power Research Institute (EPRI), where he was involved in a number of energy science issues, including managing a $2 million annual program funding power applications of superconductivity at a number of industries, universities and national labs.

From 1994 to 2007, Paul served as an annual peer reviewer of the DOE Office of Electricity Delivery and Energy Reliability 's (OE) program on the power application of superconductivity. In FY2008, line item funding for OE's power application program for superconductivity was removed from the federal budget. In FY2011, funding for OE's advanced cables and conductors program was drawn down in the anticipation that it will be eliminated for FY2012 (see *Superconductor Week*, Vol 24, No 5).

Grant: HTS Power Applications Development Community has done its Job

Grant said that while early DOE funding was essential to jump-starting superconducting wire and tape development, the technology has now been established: "The DOE funding that began to flow in the summer of 1987 was in particular very timely in getting materials efforts started. It would not have gone as fast if we had been relying on the companies interested in commercializing HTS wire and tape at the time, Intermagnetics General and American Superconductor (AMSC).

"Today, the superconductivity materials and applications development community has essentially done its job. Everything has been shown to work through successful demonstration projects in Japan and the U.S. with almost any power equipment you can think of. The RF filters for cellular ground stations have been to shown to work as well.

"So why isn't superconducting technology being deployed in grid development today? Utilities talk about the cost of the wire, that it's too expensive. In principle, you could make the wire effectively free if state and federal agencies were to tax credits for the cost of the wire, but only for the cost of the wire alone.

"Would American utilities use the technology if such a tax credit was in place? My suspicions are that the answer would be no. From the utility perspective, in the U.S. and other developed nations, in-plant and in-field efficiencies with regard to generation and transmission are pretty good.

"The utilities don't have a strong incentive or a compelling need to deploy a technology that's only a few percent more efficient than what they've got now. And they know how to use and deploy current technology to service the electrical infrastructure of today and to grow it if need be.

"A concern regarding the implementation of superconducting technology I have heard from some utilities is that they would have to hire engineers that would be trained in and familiar with such technology. Then they would have to deal with labor unions in terms of defining new job classifications and salaries that would be commensurate with that skill.

"These issues are also responsible for some utility reluctance to deploy non-superconducting smart grid technologies that have been around for years. The culture in the energy sector is one in which technology at best is 50% of the equation and the rest involves social and political issues."

Grant said he felt the cancellation of DOE funding for advanced superconductivity power application research was the right decision: "At EPRI I was a peer reviewer of DOE applied superconductivity programs every year until 2008. Over the last 3 years, from 2005 to 2007, I told the DOE I felt that the lab guys had done a wonderful job and that everything works. The wire is kind of pricey, but it's not in my opinion what's holding its use in power applications back.

"Therefore I recommended shutting down the OE program funding advanced superconductivity cable research. I know a few other reviewers with industrial experience who also felt that HTS technology had been shown to work.

"While DOE project managers in smart grid and enhanced transmission technologies are free to explore superconductivity if they feel that there is promise, a line item for superconductivity doesn't need to be there. There's been talk that some Office of Basic Energy Science (BES) money might be spent on power device development, but I haven't seen any clues that's going to happen yet."

Grant: Mega-Projects Opportunities for HTS

Grant said that some of the largest projects in the energy sector could offer opportunities for the cost-effective deployment of superconducting technology: "If you are free-market oriented, you have to figure out how to make money deploying HTS technologies. Mega-projects are the only opportunity that I see at present, what I call the Large Hadron Colliders (LHC) of the energy sector.

"An example is the Mackenzie Valley gas pipeline project that's being laid from the Mackenzie River basin in Canada's Northwest Territories down to the U.S. It has been in planning for 37 years and is now scheduled to begin construction in 2013.

"When it is fully operating, it is going to wheel 18 GW thermal of methane, and 60% of that methane is going to be turned into electricity through combined cycle gas turbines (CCGT) when it gets to the U.S. That electricity could be generated at the well-head in the Northwest Territories and sent down over superconducting cables over the same right-of-way as the pipeline. It makes sense economically because of the savings in total energy transport.

"The technology is on the shelf. You could build a superconducting cable using the EPRI report containing the design for a long-range transmission DC superconducting cable (see *Superconductor Week*, Vol 24, No 8). It is a very thorough design report that would allow building not only the cable, but also the entire electronic support system for it. And it's all free.

"There are mega-projects like the Mackenzie Valley project all over the world that offer an opportunity to use superconducting cables. Another one is the proposed Sahara Solar Breeder Project (see *Superconductor Week*, Vol 25, No 15). A lot of the opportunities are related to remote power generation.

"The opportunity for incidental deployment in usual power grid applications is, in my view, not there. Power quality in the U.S. is pretty good, and when it's not, the utilities get around to fixing it sooner or later. A good indication of this is the fact that Pirelli, formerly the largest manufacturer of transmission cables in the world, put a lot of its own money into superconducting cables.

"In the early 2000s, the company decided that the margin they would make on superconducting cables did not justify their investment. They were only making 5% on their conventional cables, and the powers that be at Pirelli decided to get out of the cable business altogether to pursue more profitable opportunities elsewhere."

Grant also said that he was skeptical wind power represented a growth opportunity for superconducting generators: "AMSC has an excellent design for a 10 MW DC generator that's

pretty light (see *Superconductor Week*, Vol 24, No 16). It has very little iron in it and it can put it up on rather reasonable tower sizes.

"However, in the U.S. it's problematic whether large-scale deployment of solar and wind power will take place, especially wind. A wind farm is an ecological bombshell: it takes up so much land, a wind farm with 10 MW towers would need 250 units to equal the 2.5 GW output of the Diablo Canyon nuclear power plant in Avila Beach, CA."

DoD Maintains Interest in SC

Grant stated that the U.S. military has reasons to continue to fund superconducting technologies: "On the military side, the Air Force has always been interested in lightweight, onboard generators. One such application considered is called passive denial, which involves shooting microwaves at the enemy and disabling them without killing them.

"There are some units that are on trucks that sort of do this in Afghanistan and Iraq, but they're only effective at short range. The Air Force would like to have units that could be put aboard helicopters to generate enough RF power to effect passive denial from the air. Military aircraft are also getting loaded with more and more electronics, so onboard generation is an issue and that might represent another opportunity for superconductivity.

"The Navy has had a long-term interest in superconducting ship motors, both low- and high-T_c. The idea is to have them so lightweight that they can be put on outboard pontoons and increase their speed and run quieter. The technology has been demonstrated, and it works."

Grant: EU Repeating U.S., Japanese Experience

Grant said that superconducting power application programs in Europe remain dependent on central or member-state EU funding: "At this year's EUCAS, it felt like the Europeans are starting demonstration projects of the same type that have been going on in the U.S. and Japan for the last 12 or 15 years. It's all being done on government subsidies.

"If you ask a company like Nexans how much of their own money they are putting into superconductivity, the answer is essentially not much. They are all great plans, but they are a repetition of the U.S. and Japanese prototypes and demonstrations.

"I saw nothing about the proposed projects that represented a new radical design or deployment opportunity. I asked a guy from a Dutch utility involved in planning a cable demonstration project where he saw the load growth given that the population in the Netherlands going down. I couldn't get any clear answers.

"In China they are seeing rapid load growth and need electric power. Right now they are having a roughly 15% to 20% daily shortfall in electricity supply which they manage by carefully selected rolling blackouts in light industrial areas, a lot of which are home to foreign-owned companies. The Chinese are in a panic to build more electricity generation and transmission infrastructure in a hurry, and they just don't have the time deploy superconducting technologies.

"The China State Grid unit in Sichuan Province is building coal plants at a very rapid rate. From Sichuan they are and will be transporting the electricity 800 to 1000 miles to the east over 750 kV high-voltage transmission lines and with most of the power management being supplied by ABB and Siemens. The Chinese are in an interesting situation where they can't wait for superconductivity, there's already technology they can buy and deploy."

Grant: May be Evidence for Bipolar-mediated Pairing of HTS in Perovskites

Grant said that he was conducting independent investigations to help explain the carrier-pairing mechanism present in HTS: "In its broadest sense, HTS is an example of Bardeen, Cooper, and

Schrieffer (BCS) superconductivity. It's the pairing of two fermions through a boson field. In LTS, the boson field is composed of phonons, and we're not quite sure yet what comprises the 'bosonic glue' for the cuprates.

"I'm using density functional theory to explore various proposals. A majority of the theoretical community thinks that the pairing is mediated by some kind of spin fluctuations, but they can never seem to describe it mathematically in any way that you could calculate from first principles. For some time, Alex Mueller has proposed a model of bipolar-mediated pairing that a major portion of the theoretical community believes doesn't apply.

"However, he has very good arguments to support his position and I'm coming more and more to feel that Mueller may be on the right track. There are isotope effects in all of the HTS materials, and there wouldn't be unless the lattice itself was involved in some way or another.

"I'm also interested in computationally exploring Bill Little's old concept envisioning a conducting chain with molecules alongside that are 'polarizable,' that is they exhibit exciton formation. Excitons are bosons with characteristic energies around 25,000 K, not in the range of a few hundred K like they are for phonons. Even if you had weak BCS coupling to the excitons, the exponential factor therein would result in a T_c of around 500 K!

"So far, nobody has done that. You can get arguments from some theoreticians that it's impossible, but it would be nice to explore such models again using modern computational chemistry and physics tools like density functional theory, and that's what I'm exploring."

Grant authored an article entitled *The Great Quantum Conundrum* in the August 2011 edition of the journal Nature (Vol 476) that analyzes different theories explaining the electron-pairing mechanism in HTS. Grant also has an article in the Summer 2011 issue of Cold Facts, *Upbraiding the Utilities*, that looks at why utilities have been slow to adopt superconducting technology. ❍

Report Projects SC Magnets Market $2.94 Billion by 2017

A report by Global Industry Analysts, Inc., has projected that the global market for superconducting magnets will reach $2.94 billion by 2017. However, the report says that ongoing manufacturing glitches and cooling costs have confined the technology to use in niche applications.

The report does not attribute much of a negative impact on the global superconducting magnets market from the recent worldwide economic recession. In contrast, the report portrays an expanding industry based on growing demand for stable and energy-efficient electricity grids, renewable energy research, next-generation materials, R&D, and components for cutting-edge medical devices.

The market research report states that the Asia-Pacific region and the U.S. together account for a major share of the superconducting magnets market. Analytical instruments, including mass spectrometry (MS), ion cyclotron resonance, and nuclear magnetic resonance (NMR), are the largest markets for superconducting magnets. The report also points to the promising automotive applications for superconducting magnets, including in high-speed trains and ship propulsion systems. ❍

Linde, PHPK Building Cryocooler for NSLS-II

Linde Cryogenics, based in Tulsa, OK, is currently working with two other companies to provide a helium refrigerator for the superconducting radio frequency (SRF) cavities on the National Synchrotron Light Source II (NSLS-II). The company is working under a $7.8 million

contract originally awarded in July by Brookhaven National Lab (BNL).

"The project is about to have the preliminary design review," said James Rose, Radio Frequency Group Leader for the NSLS-II. "The project was awarded in February and is due for completion in early 2013. The cryocooler will be about 2.5 meters in diameter, 3 meters tall, and weigh 8100 kg."

Requirements Include Tight Pressure Regulations

Linde Kryoteknic in Pfungen, Switzerland, and PHPK Technologies in Columbus, OH, are also participating in the project. The cryocooler will be an 850 W refrigeration system that will cool the RF cavities to 4.8 K.

"The engineering and manufacture of the cold box (refrigerator/liquefier) will be performed by Linde Kryoteknic. PHPK will design and build the cryogenic lines and Linde Cryogenics will provide management oversight and installation and commissioning support.

"The requirements include a very tight pressure regulation of the superconducting cavity liquid helium vessels of +/- 2 mBar. To meet this requirement, a stringent design of the transfer lines and pressure drops across all components as well as the careful choice of the cold gas return control valve to the compressors is required."

NSLS-II will be a 3 billion eV electron storage ring located at BNL and designed to produce x-rays more than 10,000 times brighter than the current NSLS. Construction of the NSLS-II's ring building began in March 2009, and the facility could begin operating in 2015.

In 2009, NSLS-II received $150 million in accelerated funding under the American Recovery and Reinvestment Act. Last year, RI Research Instruments GmbH (RI) was awarded $7.7 million by BNL to supply a non-superconducting 200 MeV electron injection linear accelerator for NSLS-II (see *Superconductor Week*, Vol 24, No 16). ❍

ETH Zurich Demonstrates Teleportation Protocol

Researchers with ETH Zurich, Raytheon BBN Technologies and the University of Sherbrooke in Sherbrooke, Quebec, claim to have demonstrated the implementation of a teleportation protocol, up to the single-shot measurement step, with superconducting qubits coupled to a microwave resonator. Teleportation of a quantum state may be used for distributing entanglement between distant qubits in quantum communication and for quantum computation.

The researchers claim to show that the protocol generates a genuine tripartite entangled state of all three qubits. The researchers reconstructed the teleported state by calculating the projection of the measured density matrix onto the basis states of two qubits. The study claims an average output-state fidelity of 88% when repeating the procedure for a complete set of input states. ❍

QIB Named Financial Advisor for Qatar Proton Therapy Project

British investment company SAH Global has announced that it has appointed the Qatar Islamic Bank (QIB) as a financial advisor for SAH Qatar Proton, a proton therapy center using superconducting technology to be established in Qatar. The company hopes to have the center up and running within three years.

SAH Qatar Proton is expected to be a major element of Qatar's $605 million National Cancer Strategy (NCS) launched earlier this year. The NCS aims to make Qatar a global leader in cancer services by 2016. As planned, the Qatar center will be able to treat up to 2200 patients a year and will also serve as a training and educational center for physicians and therapists.

Feroz Agad, Chairman and CEO of SAH Global, commented: "The proton therapy centre in Qatar is the first in a number of steps in our global cancer strategy. We at SAH Global plan to build a network of proton therapy centers in the region and beyond, with SAH Qatar Proton as our prime center. We are also in discussions with governments and potential local partners throughout the Gulf Cooperation Council countries and Europe for our satellite centers and envisage this to be a long term relationship between SAH Global and our partners, including QIB." ❍

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Superconductivity Stock Index

Company Name	Symbol	Prices ending 31-Dec-2010	Prices ending 30-Sep-2011	Percentage change
American Superconductor	AMSC	28.59	3.93	-86%
Oxford Instruments	OXIG.L	11.29 *	11.03 *	-2%
Superconductor Technologies	SCON	1.52	1.5	-1%
Bruker Corporation	BRKR	16.60	13.53	-18%
Zenergy Power	ZEN.L	0.42 *	0.07 *	-83%
Superconductor Index (12/31/09 = 100)		100.00	66.29	-34%
Standard and Poor's 500		1257.64	1,131.42	-11%

The Superconductivity Stock Index is a market value index as is the S&P500. It is generated by Peregrine Communications. The year-to-date percentage change is based upon the change in market value of the companies in the index. Market value is determined by the share price times the number of shares outstanding at the end of the measured period.
* Figures are derived from closing rates on the London Stock Exchange, converted from UK Pounds to U.S. Dollars

U.S. Superconductivity Patents

Single Flux Quantum Circuits

Northrop Grumman Systems Corporation
2011-07-12
U.S. Patent No. US7977964

SC single flux quantum circuits are disclosed herein, each having at least one Josephson junction which will flip when the current through it exceeds a I_c. Bias current for the Josephson junction is provided by a biasing transformer instead of a resistor. The lack of bias resistors ensures that unwanted power dissipation is eliminated.

Electromagnetic Wave Detection Element

National Institute of Information and Communications Technology, Incorporated Administrative Agency
2011-07-12
U.S. Patent No. US7979101

It is possible to improve the negative resistance characteristic that can be expected when an SNS (SC-normal conductor-SC) structure is used as a structure unit for series connection. On the top of a SC electrode, a second SC electrode is superimposed so as to sandwich an insulation film between the first and second SC electrodes, with parts of cross sections of the second SC electrode and insulation film placed on the top. A normal SC line electrically connects the first and second SC electrodes passing along the cross section of the insulation film, thereby constituting a structure unit having a single weak link. A plurality of such structure units connected in series are prepared. At the both ends of the series the first or second SC electrode is an element connected to a leading line. The structure units are arranged so that the cross sections of the insulation films along which the normal conducting line passes are arranged in the sale direction.

Method for Laying a SC Cable

Nexans
2011-07-19
U.S. Patent No. US7979976

A method for arranging a SC cable including the step of laying the SC cable core into a cryostat with an overlength in comparison to the axial length of said cryostat. After laying the SC cable core, it is cooled to its operating temperature thereby shortening the SC cable

core relative to the cryostat. After cooling the SC cable core, the shortened SC cable core is mechanically fixed at its two ends to the ends of the cryostat. After fixing the shortened SC cable core, terminations are mounted on the ends of the cable core, such that if the SC cable core heats up, the core deforms into a wave or helix inside the cryostat, with the length change that acts on components of the SC cable being negligible.

Gravity Gradiometer

Technological Resources Pty. Ltd.

2011-07-19

U.S. Patent No. US7980130

A gravity gradiometer is disclosed which has a sensor in the form of bars which are supported on a mounting which has a first mount section and a second mount section. A first flexure web pivotally couples the first and second mount sections about a first axis. The second mount has a first part, a second part and a third part. The parts are connected by a second flexure web and the parts are connected by a third flexure web. The bars are located in housings and form a monolithic structure with the housings respectively. The housings are connected to opposite sides of the second mount section. The bars are connected to their respective housings by flexure webs. Transducers are located in proximity to the bars for detecting movement of the bars to in turn enable the gravitational gradient tensor to be measured.

Method of Manufacturing Bi-based SC Thin Films

National Institute of Advanced Industrial Science and Technology

2011-07-19

U.S. Patent No. US7981840

A well-crystallized a-axis (or b-axis) oriented Bi-based oxide SC thin film is manufactured in order to obtain a high performance layered Josephson junction using a Bi-based oxide SC. In manufacturing a well-crystallized a-axis oriented Bi-based oxide SC thin film, a plane of a single crystal substrate of $LaSrAlO_4$ or a vicinal cut substrate of a single crystal of $LaSrAlO_4$ is used, on which an a-axis oriented Bi-2223 or Bi-2201 thin film is heteroepitaxially grown at a low film forming temperature, then homoepitaxially grown on the grown film at a high film forming temperature (double temperature growth method). Although it is difficult to grow an a-axis oriented film directly on a substrate at a high temperature, an a-axis oriented Bi-2223 or Bi-2201 thin film is formed on the base by previously forming the base film at low deposition temperature.

Resistive Type SC Current-limiting Device

Siemens Aktiengesellschaft

2011-07-19

U.S. Patent No. US7981841

The conductive path of the current-limiting device is made of a strip-shaped SC, whereby the structure thereof has a metallic strip, at least one oxidic buffer, a type $AB_2Cu_3O_x$ SC layer and a metal cover layer which is arranged thereon. An intrinsically stable bifilar coil is embodied with said SC, and a distance is maintained between adjacent coil windings, wherein a distance maintainer is arranged which is transparent to the coolant.

Cryostat Having a Magnet Coil system

Bruker BioSpin GmbH

2011-07-19

U.S. Patent No. US7982566

A cryostat with a magnet coil system including SC for the production of a magnet field in a measuring volume within a room temperature bore of the cryostat has a plurality of radially nested solenoid-shaped coil sections which surround the room temperature bore and which are electrically connected in series, at least one of which being an LTS section with a conventional LTS and at least one of which being an HTS section including a HTS, wherein the LTS section is located in a helium tank of the cryostat along with liquid helium at a helium temperature. The apparatus is characterized in that the HTS section is disposed radially within the LTS section in a vacuum portion of the cryostat and is separated from the LTS section by the helium tank wall facing the room temperature bore. The HTS coil section can be reliably used in the cryostat over a long period of time.