Superconductor Week

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

June 30, 2012 Vol. 26, No. 10

Kyushu U Developing MgB_2 Pump for Cryogen Transfer

Kyushu University researchers have reportedly successfully transferred liquid hydrogen (LH2) at normal pressure using a pump system with a superconducting MgB_2 motor. The work was supported by a four-year, ¥73.45 million ($920,000) grant received in 2008 from the New Energy and Industrial Technology Development Organization (NEDO) of Japan. The program's annual budget was over ¥14,950,000 ($190,000), and project collaborators included Kyoto University and the Japan Aerospace Exploration Agency (JAXA).

"MgB_2 has a T_c of 39 K, and thus we did not test the system for liquid nitrogen transfer," said Kazuhiro Kajikawa, Associate Professor at Kyushu U who led the program to develop the MgB_2 pump.

"We carried out experiments at the temperature of LH2, 20 K, and at the temperature of liquid helium (LH), 4 K.

"The only purpose of this project was to demonstrate the transfer of LH2, and as such the system is not yet optimized. Further research and development will be required to realize this superconducting pump system.

"Such work could include the development of a MgB_2 stator winding, the optimization of the MgB_2 motor, the development of bearings to be used in LH2, and the optimization of the impeller for LH2, among other steps. I hope that such an MgB_2 pump system could be installed in LH2 tankers and hydrogen supply stations within 10 years."

HTS-ISM can Rotate like

Synchronous Motor

Kajikawa added that the pump system was initially conceived of by a project collaborator at Kyoto U: "We are using a HTS induction/synchronous motor (HTS-ISM) proposed by one of the project collaborators, Taketsune Nakamura at Kyoto U. The rotor winding in the HTS-ISM has a structure composed of a squirrel-cage-type winding that is typically used in an induction motor.

"Because of the squirrel-cage-type winding constructed of superconducting wires, the HTS-ISM can have a persistent current flow and behave like a permanent magnet. This means that it can synchronously rotate like a synchronous motor. If the motor is operated in the synchronous mode, the loss in the rotor winding can be neglected.

"We also have plans to fabricate a superconducting stator winding, though a copper stator winding was used to transfer LH2 in the recent tests. The use of a superconducting stator winding would allow us to suppress the primary winding loss two orders of magnitude less than that of a conventional copper winding cooled to 20 K.

"Hence, the primary and secondary winding losses can be neglected compared with a conventional motor. Although we used iron cores for both rotor and stator, the amount of iron in the cores and therefore iron losses can be decreased because the HTS-ISM is more powerful and compact than a conventional motor. As a result, the HTS-ISM is more efficient than a conventional motor."

HTS-ISM Attains LH2 Flow Rate of 6.5 liter/min at 1,800 RPM

Kajikawa said that the HTS-ISM attained a slightly higher flow rate for LH than LH2 at 1,800 RPM: "A maximum flow rate of 6.5 liter/min for LH2 was obtained at a rotation speed of 1,800 RPM. This value is close to the flow rate obtained for LH, about 7 liter/min at 1,800 RPM.

"A transfer tube with a 10 mm inner diameter was used in both the experiments. We tried to observe the input powers of the fabricated motor, but they seem to be very small and negligible for our measurements."

System could be used for Pumping Hydrogen into Fuel Cell Vehicles

Currently, the most common way to transfer LH2 requires a specialist versed in pressurization and discharge to transfer the material from a storage vessel to a tank. Moreover, the pressurization process is an additional step that causes energy loss.

"If we can develop a highly efficient motor that can be rotated in the LH2, an electrically-driven pump system could be realized," said Kajikawa. "The current pump is capable of transferring LH2 at ambient pressure. Both a metal storage cryostat, which contained the MgB_2 motor with an impeller, and a glass dewar vessel meant to receive the LH2 were directly connected to a vent line, whose pressure is almost at atmospheric pressure.

"Currently, it is common to have gas stations for self-transferring gasoline to vehicles. In the future, we might find similar hydrogen supply

Superconductor Week

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

Publisher: Klaus Neumann

Executive Editor: Klaus Neumann

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stations for self-transferring hydrogen to fuel cell vehicles. At that time, the cost to employ a specialist would be very expensive, and a user would self-transfer the hydrogen with an electrically-driven pump.

Previous non-SC Pump Designs Prove Inefficient for LH2

Kajikawa added that previous, non-superconducting pump designs intended to transfer LH2 were inefficient: "Japan's World Energy Network (WENET) Project came to a close about 10 years ago. The WENET Project sought to develop hydrogen utilization technologies.

"As part of the project, a conventional induction motor was developed to transfer LH2. However, the fabricated motor was inefficient. In cryogenic environments such as LH2, we have to use superconducting technology to establish a highly efficient system.

"Since this project was focused on the demonstration of LH2 transfer, it is now complete. The next steps to develop this technology should include the development of prototype systems to be installed in practical situations such as liquid hydrogen tankers, hydrogen supply stations, and so on." ❍

BEST Finalizes Technology Transfer Deal with Rosatom

Bruker Energy & Supercon Technologies, Inc. (BEST) has finalized a large-scale technology transfer contract for its Bruker HTS GmbH subsidiary to license and transfer know-how for 2G HTS YBCO ceramic tape to a subsidiary of the Russian state atomic energy corporation, Rosatom. The total contract value exceeds $25 million, and BEST revenue is expected in various increments and milestones over an approximately two-year period.

"The license is not restricted to two years," said Klaus Schlenga, Chief Technology Officer at BEST. "The two-year period mentioned above is the approximate time frame within which BEST expects to recognize revenue based on the projected completion date of deliverables."

BEST has granted a license to Rosatom to make and sell within the Russian Federation certain 2G HTS conductors, which are expected to be manufactured in Russia using BEST's proprietary pulsed laser deposition (PLD) technology and process know-how. In addition to providing a license, BEST will also provide training and education services as well as a complete 2G HTS pilot production line to Rosatom, with expected deliveries commencing in 2013. The pilot line is expected to be initially set up and commissioned at the Bruker HTS facility in Alzenau, Germany, and then transferred to the Kurtchatov Institute near Moscow.

Not All Bruker Conductor Types Included in Contract

"We will deliver a fully functional pilot-line, which will be commissioned in Alzenau before shipment to Russia," said Schlenga. "The exact terms of the license agreement are confidential. Certain conductor types developed in recent years at Bruker HTS GmbH are not included in the license.

"The license is also limited to the territory of the Russian Federation. BEST and Rosatom intend to continue a scientific exchange and are open to further collaboration on 2G wire and applications." ❍

Russian Institutes Test LH2-MgB_2 ETL

A collaboration of several Russian institutes has reportedly completed tests on a 10 meter-long hybrid liquid hydrogen (LH2)-MgB_2 energy transfer line (ETL). The hybrid ETL uses hydrogen to both cool the MgB_2 and create power from hydrogen burning. The project is being funded an undisclosed sum by the Russian Academy of

Science (RAS).

"The current tests were conducted at a low voltage of 3.3 V," said Vitaly Vysotsky, Director of the Superconducting Wires and Cables Department at the Russian Scientific R&D Cable Institute (VNIIKP). "High-voltage insulation was not tested this time.

"The purpose of this round of testing was to prove the concept of hybrid energy transfer. Both a hydrogen line and the MgB_2 cable were tested. There are currently no plans to test this cable in grid conditions.

"This project is now completed after 7.5 months. Upon conclusion of the project we have tested a real hydrogen line and MgB_2 cable, in combination a real prototype of hybrid energy transfer systems."

LH2 Carries 30 MW

The collaboration developing the cable includes the Institute of Microelectronics Nanotechnology, VNIIKP, and the Moscow Aviation Institute. The tests occurred at the Chemical Automation Design Bureau's LH2 test facility in Voronezh, Russia. During testing, the LH2 carried up to approximately 30 MW of heat energy while flowing at a rate up to 250 g/s. The MgB_2 could simultaneously carry 50 MW.

"Overall power transferred could be up to 80 MW, 30 MW transferred by LH2 as a fuel and 50 MW transferred by electricity if the superconducting cable can be made to operate at 20 kV," said Vysotsky. "Since the current carried by the MgB_2 layers can be tripled, the overall power transferred in the line could reach as high as 180 MW.

"Total energy loss during testing at 2600 A was less than 300 W. Energy loss occurred mainly in the current leads."

Second Round of Testing on Hybrid Concept in 12 Months

The design is a prototype of the ENERGY transfer system, where both LH2 and electricity are used to transfer energy. The cable previously underwent tests late last year in which LH2 was used only as a coolant, not as a medium for energy transfer (see *Superconductor Week*, Vol 25, No 22).

"LH2 cannot conduct electricity, but it is a source of a heat power," explained Vysotsky. "Burning 1 kg of hydrogen provides roughly 120 MJ to 125 MJ of energy. For energy generation, it is optimal to deliver hydrogen in a liquid state that has a temperature of 20 K.

"The cooling for the superconductor is thus free-of-charge and allows the cable to deliver extra power. The next steps in the development of this hybrid ETL are under discussion but should include a demonstration that is high voltage, a longer transfer line (~30 m), and different types of flexible cryostats."

The cable has a diameter of 26 mm and has a cavity at its core for the flow of LH2 with a diameter of 12 mm. The layer outside the core cavity contains five strips of 3.65 mm by 0.65 mm MgB_2 supplied by Columbus Superconductor spirally arranged around a bundle of copper wires. The MgB_2 has a measured I_c of 529 A at 20 K.

A second layer of LH2 circulated in a cavity between the outer cable sheath and the inner wall of the cryostat. The cable has 10 layers of Kapton as insulation that total 1 mm in thickness, estimated to be enough for 20 kV to 40 kV. The system uses current leads and has a rated current up to 3 kA to 4 kA.

VNIIKP BSCCO Cable Project Ongoing

VNIIKP tested a 200 m, 50 MVA BSCCO cable at 20 kV in 2010 (see *Superconductor Week*, Vol 24, No 7). The cable is currently awaiting a customized cryogenic system. The BSCCO cable and LH2-MgB_2 ETL projects are completely independent.

BEST recently signed a technology transfer agreement with Russia's Rosatom for BEST's 2G HTS wire. Vysotsky said that VNIIKP would be involved in some of the developments that will follow that technology transfer agreement. The organization's main tasks remain developing high current-carrying elements and cables of all types. ❍

NIMS Synthesizes SC Fullerine Nanowhiskers

Researchers with the National Institute for Materials Science (NIMS) in Tsukuba, Japan, and the Japan Science and Technology Agency (JST) in Tokyo have synthesized superconducting fullerene C_{60} nanowhiskers via potassium (K) intercalation. The work is supported by the NIMS project "Development of Novel Nanocarbon Materials and Their Functionalization" and receives roughly $30,000 per year. In addition, the work is partly supported by the Japanese Ministry of Education, Culture, Sports, Science, and Technology's (MEXT) "New Materials Science Using Regulated Nano Spaces - Strategy in Ubiquitous Elements Grant-in-Aid Scientific Research on Priority Areas" program.

"An advantage of these fullerne nanowhiskers is that they are composed of carbon and potassium," said Takeya Hiroyuki, Researcher at NIMS. "They are also as light as silk or saran wrap. They could be used in light superconducting textile wires.

"This research has just begun, and there are still many disadvantages to these fullerene nanowhiskers. They react with moisture and oxygen, and we are trying to somehow wrap the whisker to protect it from oxidation."

Nanowhiskers Prepared Using LLIP Method

The typical dimensions of the C_{60} nanowhiskers used in the experiment were 0.54 ± 0.16 μm in average diameter and 4.43 ± 2.63 μm in average length. The nanowhiskers were prepared using the liquid-liquid interfacial method (LLIP method).

A C_{60}-saturated toluene solution was taken in a glass bottle, and isopropyl alcohol was slowly added. The C_{60} nanowhiskers form at the interface of the two solutions, after which the nanowhiskers were filtered and dried in vacuum at 100°C for 2 hours.

10 mg C_{60} nanowhiskers and an appropriate amount of K were placed together into a thin quartz tube. The nominal K compositions were set at 0.0, 1.6, 2.3, 3.0, 3.3, 4.0, 4.6, and 6.0 mole ratio vs. C_{60} in K_xC_{60} nanowhiskers.

The researchers also prepared pristine and K-doped C_{60} crystals using the same procedures for a comparison with K_xC_{60} nanowhiskers. The process was conducted in a glove box to prevent the K from oxidizing. The quartz tube was sealed under a vacuum condition at 3 x 10^3 Pa, followed by heating at 200°C for between one and 36 hours in an electric oven.

After the heat treatment, superconducting properties and structure analyses were performed. Superconducting transitions were measured using a superconducting quantum interference device (SQUID) magnetometer, a MPMS-5S made by Quantum Design.

SC Volume Fractions as High as 80% Observed

The nanowhiskers showed superconducting volume fractions as high as 80%. Superconducting volume fraction is important to flow current. The nanowhiskers had a T_c of 17 K independent of the K content in the range between 1.6 and 6.0 in K-doped C_{60} nanowhiskers, while the superconducting volume fractions changed with K content.

The highest shielding fraction of a full shielding volume was observed in $K_{3.3}C_{60}$ nanowhiskers heated to 200°C. On the other hand, another K-doped C_{60} crystal had a shielding fraction of a full shielding volume that was less than 1%. ❍

U Calgary Devises Method for Microwave Pulse Storage

Researchers with the Institute for Quantum Information Science at the University of Calgary claim to have shown how to realize coherent storage and on-demand pulse retrieval entirely within a superconducting circuit. The research is supported by The Natural Sciences and Engineering Research Council of Canada (NSERC), Alberta Innovates Technology Futures (AITF), and the Canadian Institute for Advanced Research (CIFAR). The research has received CAD20,000 ($19,500).

"Superconducting circuits are one of the most promising architectures for quantum computing," said Patrick Leung, Postdoctoral Associate at U Calgary who co-authored the study. "Coherent control of microwave storage in superconducting circuits will enable quantum memory, a crucial component of a quantum computer.

"We chose a superconducting circuit called fluxonium. It is made of superconducting aluminum with aluminum oxide Josephson junctions. Fluxonium has multiple energy levels and serves as an artificial atom, making it suitable for realizing electromagnetically-induced transparency to coherently store microwave pulses that contain the quantum information.

"Moreover, fluxonium atoms were chosen for their long quantum coherence time, which is on the order of 1 μs. The properties of each fluxonium atom can be arbitrarily controlled, providing flexibility in optimizing the performance of quantum memory."

SC Artificial Atoms Needed for Pulse Control in Microwave Quantum Circuits

Coherent pulse control for quantum memory is viable in the optical domain but nascent in microwave quantum circuits. Leung said that superconducting artificial atoms had made coherent pulse control in microwave quantum circuits feasible: "Coherent pulse control in microwave quantum circuits for pulse storage requires superconducting artificial atoms to exhibit coherent phenomenon such as electromagnetically-induced transparency, which has recently become feasible."

The scheme used in the current study employed a linear array of superconducting artificial atoms coupled to a microwave transmission line. The superconducting artificial atoms are composed of superconducting circuits.

Leung said that the researchers extended existing electromagnetically-induced transparency technology in superconducting quantum circuits: "Electromagnetically-induced transparency has been demonstrated in the optical domain and has been shown in the microwave domain for a single artificial atom. Fluxonium atoms are capable of electromagnetically-induced transparency, so when a high-intensity microwave control field is shone on the atoms, they become transparent for the low-intensity microwave signal field. Our advance is to devise a feasible scheme to employ superconducting artificial atoms that exhibits electromagnetically-induced transparency for coherent control of microwave pulse storage with optimal storage efficiency.

"The scheme used in our study is theoretical but feasible. It relies on one microwave field turning on and off the transparency to store and release a microwave pulse on demand. When the control field is on, the fluxonium array becomes transparent and the signal pulse containing the quantum information enters the array without being absorbed.

"Once the pulse is inside the array, the control field is switched off to trap the pulse. Upon demand, the pulse can be retrieved by turning on the control field again.

"We have shown that coherent control of microwave pulse storage can reach 15% storage efficiency with only five fluxonium atoms and 72%

with 100 fluxonium atoms. Moreover, as the number of fluxonium atoms increases, the efficiency approaches 100% asymptotically.

“One fluxonium array stores one microwave pulse with quantum information content, depending on the encoding process. Storage time is limited to a few microseconds.

“The storage efficiency of the pulse rises with an increasing number of fluxonium atoms and decreasing separation of the atoms. The efficiency is therefore limited by the number of fluxonium atoms that can be built into a single array. The next step in this line of research is to build an array with a few superconducting artificial atoms and test multi-atom electromagnetically-induced transparency.” ❍

Cornell/Brookhaven Team Link Magnetism to Iron-based SC

Researchers from Cornell University, Brookhaven National Lab, and St. Andrews University in Scotland have reportedly measured how strongly electrons are bound together to form Cooper pairs in an iron-pnictide superconductor. Their observations support magnetic pairing theory, which eventually might be used to identify or design superconductors that function at higher T_c's. The study received financial support from DOE's Office of Science, as part of the Center for Emergent Superconductivity (CES); the U.K. Engineering and Physical Sciences Research Council; the U.S. National Science Foundation; the Japan Society for the Promotion of Science; the Academia Sinica Research Program on Nanoscience and Nanotechnology; and a Royal Society Wolfson Research Merit Award.

Experiment Confirms Magnetic Pairing Theory

“This is the first experiment to confirm the anisotropic energy gaps which are an iconic prediction of magnetic pairing theory,” said Seamus Davis of Cornell U and Director of CES. “Theorists can now quantify the parameters that go into the models because we can compare predicted anisotropic gaps with those observed.”

Scientists have long considered whether the formation of electron pairs play a key role in HTS. They hypothesized that creating antiferromagnetic materials by pointing the magnetism of electrons from adjacent atoms with the same energy level in opposite directions might enable these particles to overcome their mutual repulsion to join in Cooper pairs and become superconducting.

However, experimenting with superconducting cuprates proved to be problematic as it was difficult to get antiferromagnetic electrons to pair and form a superconductor. The discovery of iron-based superconductors in 2008 revived interest in determining whether magnetism played a role in superconductivity.

Davis noted that the group's work with pnictides may play a role in finding compounds that reach superconductivity at higher temperatures: “Once we know how magnetism generates higher T_c's, then we can search for or fabricate other compounds using this recipe to yield even higher-T_c superconductors.”

An iron atom contains five magnetic electrons moving around the crystal in separate electric bands. The researchers sought to measure the anisotropic energy gap to determine whether the magnetic interactions between electrons were generating superconductivity. Theorists had predicted what those measurements should be if this were the case.

STM Determined Energy Needed for Separating Cooper Pairs

The measurements taken by the researchers took into account the electronic bands and directions in which the electrons were traveling, which were key to testing theoretical predictions on magnetism and superconductivity. The technique devised for carrying out the measurements, multi-band Bogoliubov quasiparticle scattering interference, confirmed the predictions of the theorists.

The researchers used a scanning tunneling microscope (STM) to measure how much energy was necessary to pull a Cooper pair apart. Scanning LiFeAs crystals that became superconducting at 15 K, the researchers found three of the five possible electron bands.

The strength of the "glue" binding the Cooper pairs together differed for each band and depended on the direction the electrons were traveling. Davis noted that his group would continue its work: "We plan to conduct the same type of experiment on a different iron-based compound." ❍

Imperial College Describes P-Wave SC Phase in Black Holes

Researchers at Imperial College in London have constructed new five-dimensional black hole solutions that describe a new phase of matter, which resembles a helical p-wave superconductor. They reportedly used Anti De Sitter/Conformal Field Theory (AdS/CFT) correspondence to determine the temperature dependence of the pitch of the helix.

The research incorporates recent efforts to use string theory as a problem-solving tool for theoretical physics, especially involving quantum physical phase transitions. Work in this cross-cutting field has developed within the scope of AdS/CFT correspondence, a duality that maps quantum mechanical problems involving strongly-coupled systems to questions that can be addressed through string theory.

Applying AdS/CFT to HTS

"One of the most tantalizing applications of this duality is in the context of HTS," said Aristomenis Donos, who, with Jerome Gauntlett of Imperial College, conducted the research. "We are interested in novel realizations of superconductivity via black holes in the hope that they might correspond to similar phases that are seen in nature. We are particularly interested in the zero temperature ground states, which the AdS/CFT can provide exactly.

"Over the past few years a new interdisciplinary field has emerged composed of string theorists and condensed matter theorists with the aim of answering questions in condensed matter theory for which no other alternative approach has given sensible results. The first concrete result in this direction was the construction of black holes that describe an s-wave superconductor phase transition.

In models developed by string theorists, when a black hole is cooled to a sufficiently cold temperature, a halo of charged matter suddenly forms. The three-dimensional surface for this event corresponds to electrons changing phase and starting to flow without resistance, resulting in a superconducting material.

P-Wave SC Similar to Liquid Crystal Phases

"Over the past few years the research community has been actively pursuing what other phases of matter can be described or predicted in this holographic context," noted Donos. "Our latest work describes a new phase that has been suggested to exist in non-centrosymmetric superconductors studied by condensed matter theorists.

"This phase can be thought of as a p-wave superconductor. Unlike the case of s-wave superconductors, the order parameter in this case is a vector with the novel feature that it now forms a helix in space much like the helical structure appearing in the chiral nematic phases of liquid crystals."

Donos said the Imperial College researchers plan to continue working with helical p-phase superconductors: "An interesting feature of the AdS/CFT correspondence is that it can be used to compute transport properties in the media we are considering. We know from liquid crystal physics that cholesteric phases have very striking properties with regard to light propagation. We would very much like to better understand these properties - conductivity/resistivity for electric currents in a superconductor with helical structure." ❍

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U.S. Superconductivity Patents

Method for the Formation of Doped Boron
Specialty Materials, Inc.
2012-04-24
U.S. Patent No. US8163344
A chemically-doped boron coating is applied by chemical vapor deposition to a silicon carbide fiber and the coated fiber then is exposed to magnesium vapor to convert the doped boron to doped MgB_2 and a resultant SC.

Fabrication of MgB_2 SC Tape and Wire
National Institute for Materials Science
2012-05-08
U.S. Patent No. US8173579
In a fabrication method of a MgB_2 SC tape and wire by filling a tube with a MgB_2 SC powder and forming it into a tape or wire, a fabrication method of a MgB_2 SC tape (and wire) which is characterized by using a MgB_2 SC powder having a high J_c owing to its lowered crystallinity and having potential for excellent grain connectivity as the MgB_2 SC powder. Provided are a fabrication method of a MgB_2 SC tape and wire which can fabricate a MgB_2 SC tape and wire having a level of J_c sufficiently high for practical applications and homogeneous quality throughout its length by an ex-situ process employing a material of the composition suitable for its working environment as the sheath material, and a MgB_2 SC tape and wire thereby fabricated.

SC Cable Line
Sumitomo Electric Industries, Ltd.
2012-05-08
U.S. Patent No. US8173897
A SC cable line includes a heat insulation pipe for a fluid for transporting LH2, a SC cable housed in the heat insulation pipe for a fluid, and heat exchange means for performing a heat exchange between LH2 and a refrigerant of the cable. The SC cable includes a cable core inside a heat insulation pipe for a cable and is housed in the heat insulation pipe for a fluid to form a low-temperature environment around the cable and a double heat insulation structure including the heat insulation pipe. Therefore, since heat intrusion into the SC cable is reduced and the refrigerant is cooled with LH2, the line can reduce energy for cooling the refrigerant.

Multifilament SC
European Advanced Superconductor GmbH & Co. KG
2012-05-08
U.S. Patent No. US8173901
A multifilament SC has a core area, several SC filaments and reinforcement filaments. The SC filaments and the reinforcement filaments are arranged so that they have a regular 2D matrix in the cross-section of core area. The reinforcement filaments consist of tantalum or a tantalum alloy, and the SC filaments each have a core, made from a powder metallurgically-produced SC, which is enclosed by an inner shell, made of a non-SC metal or a non-SC alloy. The core area is enclosed by an outer shell made of a non-SC metal or a non-SC alloy.

Gantry for Particle Therapy
Brookhaven Science Associates, LLC
2012-05-08
U.S. Patent No. US8173981
A particle therapy gantry for delivering a particle beam to a patient includes a beam tube having a curvature defining a particle beam path and a plurality of fixed field magnets sequentially arranged along the beam tube for guiding the particle beam along the particle path. In a method for delivering a particle beam to a patient through a gantry, a particle beam is guided by a plurality of fixed field magnets sequentially arranged along a beam tube of the gantry and the beam is alternately focused and defocused with alternately-arranged focusing and defocusing fixed field magnets.

Coupling Qubits

D-Wave Systems Inc.
2012-05-08
U.S. Patent No. US8174305
A ladder structure is ferromagnetically coupled to a first qubit where the ladder structure has a monostable energy potential in use, such that the first qubit and the ladder structure effectively operate as a single qubit. The ladder structure and first qubit may be coupled via a SC flux coupler. The ladder structure may be a chain of at least two ferromagnetically coupled ladder elements. A value for each ladder element may be less than about 1.

Creating a Magnetic Field via SC Magnet

Commissariat a l'Energie Atomique et aux Energies Alternatives; Centre National de la Recherche Scientifique
2012-05-08
U.S. Patent No. US8174803
The present invention relates to a system for creating a magnetic field via a SC magnet intended to produce said magnetic field. The system according to the invention comprises a first branch including the SC magnet formed by a coil inductance in series with a residual resistance, a second branch comprising a protection resistance and a third branch comprising a power source. Furthermore, the system comprises a fourth branch formed by a resistance mounted in series with a current-limiting SC device switching from a low-resistance state to a high-resistance state when the current passing therethrough exceeds a breaking current, said first, second, third and fourth branches being mounted in parallel.

Quantum and Digital Processor Hybrid

D-Wave Systems Inc.
2012-05-08
U.S. Patent No. US8175995
Quantum and digital processors are employed together to solve computational problems. The quantum processor may be configured with a problem via a problem Hamiltonian and operated to perform adiabatic quantum computation and/or quantum annealing on the problem Hamiltonian to return a first solution to the problem that is in the neighborhood of the global minimum of the problem Hamiltonian. The digital processor may then be used to refine the first solution to the problem by casting the first solution to the problem as a starting point for a classical optimization algorithm. The classical optimization algorithm may return a second solution to the problem that corresponds to a lower energy state in the neighborhood of the global minimum, such as a ground state of the problem Hamiltonian. The quantum processor may include a SC quantum processor implementing SC flux qubits.

Qubit State Readout

D-Wave Systems Inc.
2012-05-01
U.S. Patent No. US8169231
A SC readout system includes a computation qubit; a measurement device to measure a state of the computation qubit; and a latch qubit that mediates communicative coupling between the computation qubit and the measurement device. The latch qubit includes a qubit loop that includes at least two SC inductors coupled in series with each other; a compound Josephson junction that interrupts the qubit loop that includes at least two Josephson junctions coupled in series with each other in the compound Josephson junction and coupled in parallel with each other with respect to the qubit loop; and a first clock signal input structure to couple clock signals to the compound Josephson junction.

Catheter Electrode for MRI

St. Jude Medical, Atrial Fibrillation Division, Inc.
2012-05-08
U.S. Patent No. US8175679
An electrode may have a main body of electrically conductive material extending along an axis and having a proximal end and a distal end. The body may be configured to emit electrical energy in accordance with a predefined diagnostic or therapeutic function. The body may have a groove disposed over an outermost surface of the body. The electrode may also include a MRI tracking coil disposed in said groove. The MRI tracking coil may comprise electrically insulated wire, for example.