Extra May, 2013 Date of Issue: May 9, 2013

Superconductivity Web21

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World Project Now for Superconductor

Save Earth by Superconductor

This year ISTEC has started the special feature on the current world projects for HTS superconductor and its application.

This May issue, Dr. Xiao of IEE, CAS and Prof. Han of Tsinghura University, introduces China activity. Now China is increasing more and more their activity in superconductivity R&D as in other areas. Due to the large number of population and energy consumption, we can easily understand the significance of using superconductor and its application in China to save energy for the future.

ISTEC
YUTAKA YAMADA

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Recent Progress of Superconducting Technology for Power in China

Liye Xiao, Institute of Electrical Engineering, Chinese Academy of Sciences
Zhenghe Han, Tsinghua University

Abstract

China is a country where most of the power sources locate at the west and northwest area while most of the load centers locate at the south and east area, this distribution picture of power and load leads to a large-scale national power grid in which all regional grids are interconnected and thus the national power grid covers almost all of the territory of the country. For this reason, it has been a serious task to keep the stability and to reduce the transmission losses of the power grid. As superconducting technology would be a possible solution to enhance the stability and reduce the losses, it has been supported by the China's Ministry of Science and Technology (MOST) through a project named "863 Plan-On Superconducting Technology", and the Chinese Academy of Science (CAS). Recently, power grid companies such as State Power Grid Company and South Power Grid Company also pay more attention on the superconducting technology for power grid. In this report, we will give a view of the recent progress of superconducting material and its application in power grid, including the YBCO tapes, BSCCO tapes, iron-based wires and the demonstration system of a 10 kV superconducting power substation, superconducting DC power cable, fault current limiter and SMES.

1. Superconducting Materials

1.1 R&D for YBCO and BSCCO in China

A coated conductor R&D project leading by Shanghai Jiao Tong University (SJTU) was supported by the Ministry of Science and Technology (MOST). At the end of 2010, SJTU successfully fabricated 100 m long coated conductor tape with 194 A/cm at 77 K, self field. Now 100 m long and 300 A/cm class tapes can be fabricated. Northwest Institute for Nonferrous Metal Research (NIN) has established a Ni-W alloy RABiTS tape fabrication line with 30-50km/year capacity.

Bi-2223 tape is mainly produced by the company of InnoST with a capacity of 200 km/year. The standard long tape is of 120 A at 77 K, self field. InnoST also supplies insulated Bi-2223 tape and Ag-Au alloy sheathed Bi-2223 tape for current leads. InnoST also supplies HTS current leads and coils to various customers.

1.2 Iron-based superconducting wires and tapes

Recently, a group leaded by Dr. Yanwei Ma at the Institute of Electrical Engineering (IEE), Chinese Academy of Sciences first developed a PIT processing strategy to obtain c-axis textured Pb-doped $Sr_{1-x}K_xFe_2As_2$ (Sr122) tapes with Fe sheath by flat rolling. They fabricated high performance textured Sr122 tapes by optimized a cold deformation process plus Sn addition, which are both effective ways to improve grain connectivity. At 4.2 K, the J_c values showed extremely weak magnetic field dependence and reached high values of 1.7×10^4 A/cm^2 at 10 T and 1.4×10^4 A/cm^2 at 14 T, respectively, as seen in Figure 1. These values are by far the highest ever reported for iron based wires and approach the J_c level desired for practical applications. Most recently, based on the techniques used in the single-core iron pnictides wires, Ma's group also produced the Ag/Fe clad seven-core multifilamentary $Sr_{1-x}K_xFe_2As_2$ wires and tapes, which had a high transport J_c up to 2.1×10^4 A/cm^2 at 4.2 k in self field, and shows very weak field dependence at high fields (*Appl. Phys. Lett.* 102 (2013) 082602). These results clearly demonstrated the strong potential of using iron based superconductors for high field applications.

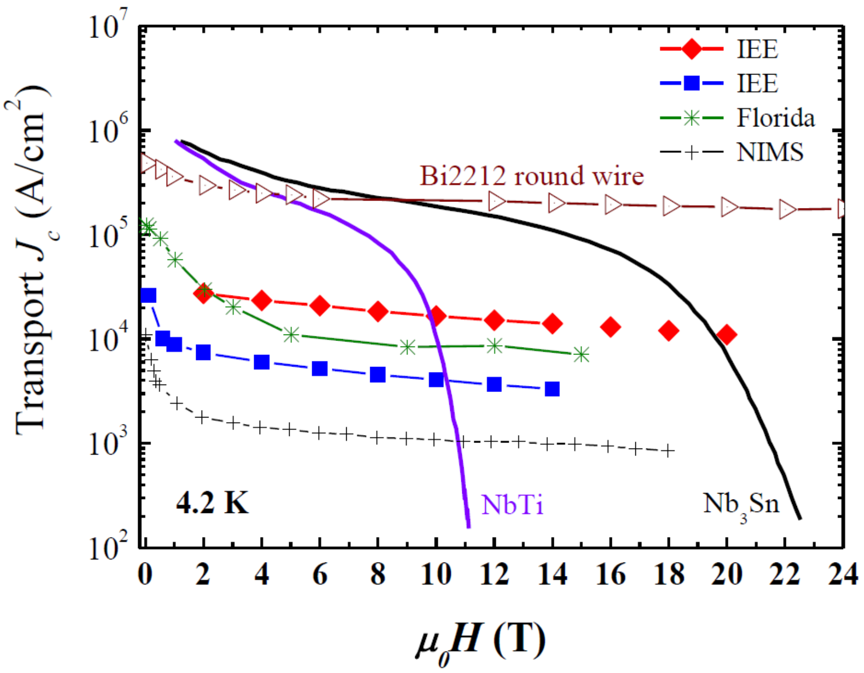

Fig. 1 Transport J_c values of textured Sr122 tapes at 4.2 K plotted as a function of applied magnetic fields along with other Fe-based superconducting wires, Bi2212 and conventional Nb based superconducting wires.

2 Superconducting Technology for Power Grid

2.1 The 10kV Superconducting Power Substation [1]

The project was sponsored by IEE during last decade. The superconducting power substation was built by integration of a 3-phase 75m-long 10kV/1.5kA high T_c superconducting (HTS) po wer cable, a 3-phase 10kV/1.5kA SFCL, a 3-phase 10kV/0.4kV HTS transformer with capacity of 630 kVA, and a 1 MJ/500kVA SMES which have been demonstrated at substations or distribution system during 2004-2008, and then all the above superconducting power equipment were integrated at Baiyin Indus trial Park of Gansu Province. An overview of this substation is shown in Figure 2.

Since the demonstration of the substation at the beginning of February 2011, there has been neither fault in the distribution system nor electrical breakdown of the superconducting power equipment. A cryogenic fault in the refrigeration syste m can be recovered by re placement of cryostat of the power transformer and the LN_2 pump. For above reas on, the oper ation of the superconducting power substation demonstrates that reliability and power quality of the power supply have been greatly improved by the SMES.

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Fig. 2 A view of the superconducting power substation

2.2 The 360m/10kA Superconducting DC Power Cable [2]

In order to demonstrate the possible application of superconductor for DC power transmission, IEE started to develop a 10 kA HTS D C power cable in 2007. In order to test the cable to carry current capacity of 10 kA, the cable is then demonstrated in Zhongfu Group which is company to produce aluminum.

The power cable now has been successfully installed at Henan Zhongfu Group in September 2012. In order to test the bending p erformance of the cable, the installation of the HTS DC cable is designed to be bended 9 times, among wh ich three are vertical bending and six are horizont al bending, and the minimum bending radius is 3 m. The power cable, which connects the substation and the bus-bar of an aluminum electrolyzing workshop, now is operated to serve for the power s upply of the fa ctory together with the conventional transmission conductor. An overview of the installed cable is shown in Figure 3.

Fig. 3 An overview of the 10kA HTS DC power cable after installation.

2.3 220kV/800A Superconducting Fault Current Limiter [3]

Recently, saturated iron-core type FCL have been developed in China by Innopower Superconducting Power Cable Company. After the factory tests in 2011, the 220kV/800A FCL was disassembled into five parts and shipped to Shigezhuang substation of Tianjin, China. Installation of the device was completed in the first quarter of 2012. Figure 4 shows the FCL after installation. Acceptance tests on this device were carried out by Tianjing Power Company. The results show that the FCL was restored to its functional capabilities after undergoing disassembling, shipment, reassembling, and in stallation configurations and is qualified for grid operation. Live-grid operation of this FCL will be proceeded to test its performance and reliability.

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Fig. 4 A view of the 220kV/800A FCL after installation at Shigezhuang substation in Tianjin

2.4 The 1MJ/500kVA HTS SMES [4,5]

The SMES was fabricated by BSCCO tape and operated at 4.2 K. The coil for the SMES consisted of 44 double pancakes, among which pancakes at two ends were wound with single tape, and the other 38 double pancakes were wound by two tapes in parallel. Because of the anisotropic effect, 3 coils at each end were operated in parallel in order to obtain the same critical current as each of the other pancakes. The SMES was tested at Beijing Mentougou Substation before it was moved to the 10 kV Superconducting Substation at Baiyin City, Gansu Province. The operation of the SMES shows that the power quality can be effectively improved by SMES, an example shows that the distortion of grid current has been greatly lowered from 5.13 % to as low as 1.33 %.

2.5 The 1MW HTS Motor

A 1 MW HTS Motor (as shown in Figure 5) has been made by Wuhan Institute of Marine Electric Propulsion by using of Bi-2223 tape. The motor employs synchronous structure of 4 HTS poles with a rotating speed of 500-rpm.

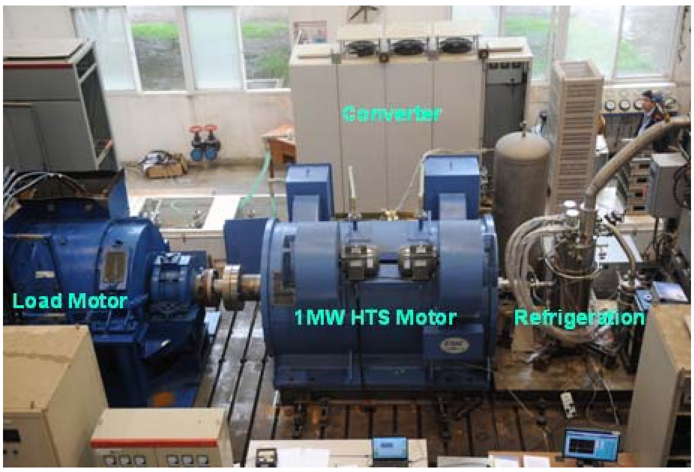

Fig. 5 A view of the 1 MW HTS motor

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3. Summary

Since the superconducting power technology would be a possible solution for the stability and efficiency of China's power grid, the R&D on this field has been supported by the MOST, CAS and power grid company. In last few years, it has reached significant progresses in the R&D for HTS materials such as BSCCO tapes, YBCO tapes and Iron-based wires, and fabrication and demonstrations on superconducting power substation, DC power cable, Fault current limiter, SMES and motor have been successfully conducted in China.

Reference

[1] Xiao L.Y., Dai S.T. and Lin L.Z. *et al*. (2012), *Development of the World's First Superconducting Power Substation*, IEEE Transactions on Applied Superconductivity, Vol.22, 5000104.

[2] Xiao L.Y., Dai S.T. and Lin L.Z.*et al.* (2012), *Development of a 10kA HTS DC Power Cable*, IEEE Transactions on Applied. Superconductivity, 22, 5800404.

[3] Xin Y., Gong W. Z., Cui J.B. *et al.* (2013), *Factory and Field Tests of a 220 kV/300 MVA Statured Iron-Core Superconducting Fault Current Limiter*, IEEE Transactions on Applied Superconductivity, 23, 5602305 (to be published).

[4] Xiao L.Y., Wang Z.K., Dai S.T., Zhang J.Y., Zhang D., Gao Z.Y., Song N.H., Zhang F.Y., Xu X. and Lin L.Z. (2008), *Fabrication and Tests of a 1MJ HTS Magnet for SMES*, IEEE Transactions on Applied Superconductivity, 18, 770-773.

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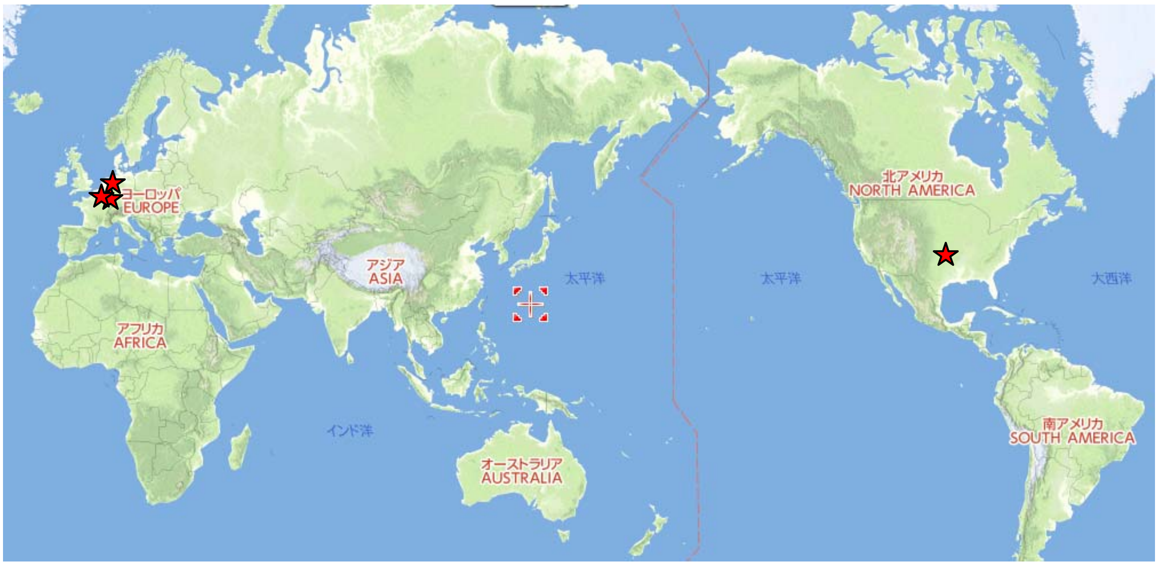
What's New in the World of Superconductivity (March, 2013)

초전도 뉴스 –세계의 동향-

超导新闻 -世界的动向-

chāo dǎo xīnwén - shìjiè de dòngxiàng-

Yutaka Yamada, Principal Research Fellow
Superconductivity Research Laboratory, ISTEC



★News sources and related areas in this issue

▶ Wire 선 재료 线材料 [xiàn cáiliào]

Hannover Messe Exhibition

This work was subsidized by JKA using promotion funds from KEIRIN RACE.

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Superconductor Technologies Inc. (April 1, 2013)

Superconductor Technologies Inc. (STI) has announced that it will exhibit its Conductus® superconducting wire in the SuperConductingCity at the Hannover Messe World Trade Fair, to be held from April 8 to April 12, 2013, in Hannover, Germany. This trade show is the largest in the world to focus on topics such as renewable and conventional power generation, power supply, transmission, distribution, and storage. Adam Shelton, Vice President of Marketing and Product Line Management at STI, commented, "SuperConductingCity is an ideal venue to interface with multiple customer groups in a single setting. We plan on building on last year's successes in Hannover, which proved to be an ideal environment to launch our Conductus 2G HTS wire product line. This year, we will showcase Conductus wire and participate in a joint effort with the City of Austin, Texas Chamber of Commerce." SuperConductingCity is the world's leading showcase for the superconductor industry.

Source: “Superconductor Technologies Exhibiting in SuperConductingCity at Hannover Messe World Trade Fair”
Superconductor Technologies press release (April 1, 2013)
URL:http://phx.corporate-ir.net/staging/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1801789&highlight
Contact:Investor Relations, Cathy Mattison or Becky Herrick of LHA for Superconductor Technologies Inc., invest@suptech.com, ; HTS Wire, Mike Beaumont of STI, mbeaumont@suptech.com

►Power Application 전력응용 电力应用 [diànlì yìngyòng]

AmpaCity Project

Nexans (April 2, 2013)

Nexans, together with RWE Deutschland AG, has announced the completion of the development phase and prototype testing for a new superconductor cable intended for the “AmpaCity” project. Production on the space-saving and energy-efficient 10-kV HTS cable system, which is 1 km in length, began in March. The cable will be used to replace a 110-kV copper cable in the city of Essen, Germany, at the end of 2013 and will be capable of transporting up to 40 MW of power. The HTS cable will be able to transport 5 times the electricity of the copper cable it replaces while maintaining the same outer diameter. Once installed, the three-phase, concentric 10-kV cable will be the longest installed superconductor cable in the world. The combination of a superconductor cable with a superconducting fault current limiter (SFCL) will also represent a world first. The SFCL will be produced at Nexans SuperConductors GmbH and will be used to protect the grid and the cable from overloads caused by short circuit currents. Experts anticipate that such innovative cable systems will soon be in a position to compete with copper solutions in energy-intensive applications from both a performance and cost-effective perspective.

Source: “Type testing of the recently developed superconductor cable for the “AmpaCity” project successfully completed”
Nexans press release (April 2, 3013)
URL:http://www.nexans.com/eservice/Corporate-en/navigatepub_142482_-32599/Type_testing_of_the_recently_developed_superconduc.html

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Contact: Angéline Afanoukoe Press relations, Angeline.afanoukoe@nexans.com

►Basics 기초 基础[jīchǔ]

Tsunami in a Superconductor

Helmholtz-Zentrum Dresden-Rossendorf (March 27, 2013)

An international team of researchers at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) have succeeded in selectively influencing the conductivity of superconductors using a powerful terahertz laser; the precise laser light turns into a vortex that then moves through the superconductor like a tsunami. In a typical superconductor, electrons flow within a superconducting layer without resistance but can also "tunnel" through insulating layers located between the superconducting layers. The mechanisms of superconducting are thought to differ within and between layers. The HZDR group was interested in how the electrons transport superconducting properties vertically from one layer to another and whether this transport could be controlled without disrupting the superconductivity within the horizontal layers. The researchers used a free electron laser that generates flashes of a specific, adjustable laser wavelength. If these short terahertz flashes penetrate the material layers of the superconductor at the correct frequency, they can selectively and locally deactivate the superconductivity by directly changing the tunneling properties of the electrons between the superconducting layers. The light generates a pair of normal-conducting vortex currents that rotate in opposite directions; these vortices move through the superconductor with the light, forming a so-called soliton wave. These waves retain their shape regardless of any faults in the superconductor, resembling the behavior of other known soliton waves such as tsunamis. These light-generated vortices inside superconductors could lead to a number of new applications, such as the storage and transport of information. The group's results have been published in *Nature Materials*.

Source: "Light Tsunami in a Superconductor"
Helmholtz-Zentrum Dresden-Rossendorf press release (March 27, 2013)
URL:http://www.hzdr.de/db/Cms?pOid=38838&pNid=0
Contact:Dr. Christine Bohnet Press officer at HZDR, c.bohnet@hzdr.de

Particle Discovered at CERN is a Higgs Boson

CERN (March 13, 2013)

CERN has presented preliminary new results that provide further information of the particle discovered last year. After analyzing a data volume 2.5 times larger than that available at the time of the previous announcement, made in July 2012, the report concluded that the new particle is looking more and more like a Higgs boson, which is the particle linked to the mechanism that gives mass to elementary particles. Whether the particle is the Higgs boson of the Standard Model of particle physics or possibly the lightest of several bosons predicted in some theories that expand upon the Standard Model remains uncertain and will require further analysis. Dave Charlton, spokesperson for ATLAS, commented, "The beautiful new results represent a huge effort by many dedicated people. They point to the new particle having the spin-parity of a Higgs boson as in the Standard Model. We are now well started on the measurement program in the Higgs sector." To determine whether the particle in question is the Standard Model Higgs boson, researchers will measure the precise rate at which the boson decays into other particles and will compare the observed results with predictions. Characterizing these decay modes will require much more data to be collected from the LHC.

Source: "New results indicate that particle discovered at CERN is a Higgs boson"
CERN press release (March 13, 2013)
URL:http://press.web.cern.ch/press-releases/2013/03/new-results-indicate-particle-discovered-cern-higgs-boson
Contact: press.office@cern.ch

►Management and Finance 경영정보 经营信息[jīngyíng xìnxī]

SUPERCONDUCTOR TECHNOLOGIES INC. 2012 Finacial Report&Wire Progress

Superconductor Technologies Inc. (March 7, 2013)

Superconductor Technologies Inc. has reported its fourth-quarter and year-end results for the periods ending December 31, 2012. Net revenues for the fourth quarter totaled $1.1 million, compared with $284,000 for the same period in the previous fiscal year. The net loss for the quarter was $2.3 million, compared with a net loss of $3.1 million for the same period in the previous fiscal year. Net revenues for the full year amounted to $3.5 million, which was the same as the $3.5 million earned in the previous fiscal year. The net loss for 2012 was $10.9 million, compared with a net loss of $13.4 million for the same period in the previous fiscal year. Jeff Quiram, STI's president and chief executive officer, commented, "2012 has been a watershed year as STI strives to become a leading producer of second generation (2G) HTS wire. In the past year, we installed a complete suite of Conductus® wire manufacturing equipment at our new Advanced Manufacturing Center of Excellence facility in Austin. Our IBAD system is operational and has been producing fully compliant material for several quarters. Our new SDP system is operational, and in the last two weeks we produced 50 meters of 10 centimeter wide substrate in a continuous run that met our substrate performance requirements. This is a significant milestone in our efforts to produce wider and longer wire substrate, which we will utilize to produce longer lengths of Conductus wire. We have completed several production runs of our new 100 meter RCE tool. Our technical team continues to make very significant progress in turning up this machine, and we believe we will solve the remaining operational issues in the near future." Quiram later added, "In the fourth quarter, we also shipped Conductus wire samples to several new potential customers for qualification testing in fault current limiter and superconducting motor applications. In summary, STI is producing 2G HTS wire that exceeds previously

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published industry performance metrics. We enter 2013 ready to begin pilot production of Conductus in lengths of up to 100 meters." As of December 31, 2012, STI had $3.6 million in cash and cash equivalents.

Source: "Superconductor Technologies Reports 2012 Fourth Quarter and Year-End Results"
Superconductor Technologies Inc. press release (March 7, 2013)
URL:http://phx.corporate-ir.net/staging/phoenix.zhtml?c=70847&p=irol-newsArticle&ID=1793486&highlight
Contact: Investor Relations, Cathy Mattison or Becky Herrick of LHA for Superconductor Technologies Inc., invest@suptech.com, ; HTS Wire, Mike Beaumont of STI, mbeaumont@suptech.com

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