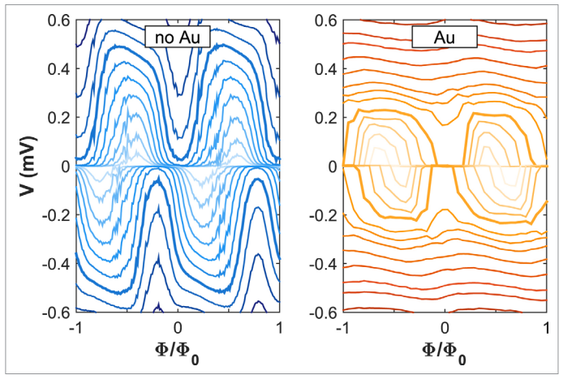
Improved noise performance of ultrathin YBCO Dayem bridge nanoSQUIDs

R Arpaia, M Arzeo, R Baghdadi, E Trabaldo, F Lombardi and T Bauch

Abstract

We have fabricated $YBa_2Cu_3O_{7-\delta}$ (YBCO) nano superconducting quantum interference devices (nanoSQUIDs), realized in Dayem bridge configuration, on films with thickness down to 10 nm. The devices, which have not been protected by a Au capping layer during the nanopatterning, show modulations of the critical current as a function of the externally applied magnetic field from 300 mK up to the critical temperature of the nanobridges. The absence of the Au shunting layer and the enhancement of the sheet resistance in ultrathin films lead to very large voltage modulations and transfer functions, which make these nanoSQUIDs highly sensitive devices. Indeed, by using bare YBCO nanostructures, we have revealed an upper limit for the intrinsic white flux noise level $S_{\Phi,w}^{1/2} < 450\ n\Phi_0\ Hz^{-1/2}$.

2017 *Supercond. Sci. Technol.* **30** 014008



Observation of reversible critical current performance under large compressive strain in $Sr_{0.6}K_{0.4}Fe_2As_2$ tapes

F Liu, C Yao, H Liu, C Dai, J Qin, L Ci, Z Mao, C Zhou, Y Shi, H Jin, D Wang and Y Ma

Abstract

Iron-based superconductors have caused great interest regarding high-field applications due to their good properties. A common fabrication route for 122-type wires and tapes is the *ex situ* powder-in-tube (PIT) process. From the point of application in the high magnetic field, where high electromagnetic forces are present, the conductor strength and its tolerance to the mechanical load are important issues. In order to understand the comparatively integrated critical current characterization of the Sr-122 tape under axial strain, the so-called U-spring setup was used to test a silver-sheathed $Sr_{0.6}K_{0.4}Fe_2As_2$ tape sample with a single core over a wide range of applied axial strain (−0.6% ~ 0.3%). It was found that when the sample was compressed, the critical current performance showed reversibility; meanwhile the irreversible tensile strain limit was quite low. The Sr-122/Ag tape shows very good performance under compression, and a possible conductor design should be considered to make the superconductor work at proper compressive strain states for future applications.

2017 *Supercond. Sci. Technol.* **30** 07LT01

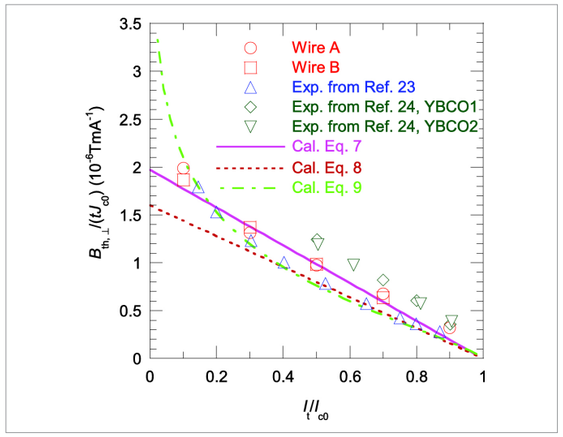
Dynamic resistance of a high-T_c coated conductor wire in a perpendicular magnetic field at 77 K

Zhenan Jiang, Ryuki Toyomoto, Naoyuki Amemiya, Xingyou Zhang and Chris W Bumby

Abstract

Superconducting high-T_c coated conductor (CC) wires comprise a ceramic thin film with a large aspect ratio. This geometry can lead to significant dissipative losses when exposed to an alternating magnetic field. Here we report experimental measurements of the 'dynamic resistance' of commercially available SuperPower and Fujikura CC wires in an AC perpendicular field. The onset of dynamic resistance occurs at a threshold field amplitude, which is determined by the total DC transport current and the penetration field of the conductor. We show that the field-dependence of the normalised magnetisation loss provides an unambiguous value for this threshold field at zero transport current. From this insight we then obtain an expression for the dynamic resistance in perpendicular field. This approach implies a linear relationship between dynamic resistance and applied field amplitude, and also between threshold field and transport current and this is consistent with our experimental data. The analytical expression obtained yields values that closely agree with measurements obtained across a wide range of frequencies and transport currents, and for multiple CC wires produced by different wire manufacturers and with significantly differing dimensions and critical currents. We further show that at high transport currents, the measured DC resistance includes an additional nonlinear term which is due to flux-flow resistance incurred by the DC transport current. This occurs once the field-dependent critical current of the wire falls below the DC transport current for part of each field cycle. Our results provide an effective and simple approach to calculating the dynamic resistance of a CC wire, at current and field magnitudes consistent with those expected in superconducting machines.

2017 *Supercond. Sci. Technol.* **30** 03LT01



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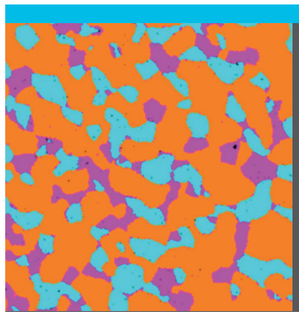

Superconductor Science and Technology

Highlights of 2017

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I am delighted to present the *Superconductor Science and Technology* (SUST) highlights of 2017. These papers provide an example of the high quality, innovative and interesting work that was published in the journal last year. The papers were chosen based on a number of criteria, including presentation of outstanding research, popularity with our online readership and high praise from referees.

We look forward to working with you this year and hope that you will consider the journal for your next paper.

Lucy Smith
Publisher
Superconductor Science and Technology

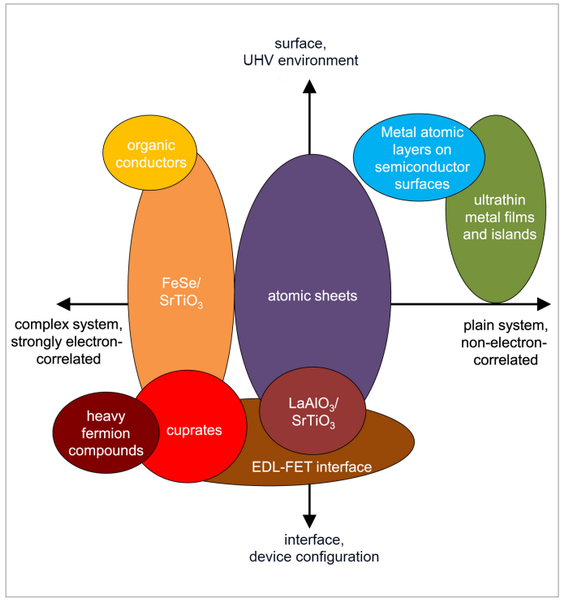
Two-dimensional superconductors with atomic-scale thickness

Takashi Uchihashi

Abstract

Recent progress in two-dimensional superconductors with atomic-scale thickness is reviewed mainly from the experimental point of view. The superconducting systems treated here involve a variety of materials and forms: elemental metal ultrathin films and atomic layers on semiconductor surfaces; interfaces and superlattices of heterostructures made of cuprates, perovskite oxides, and rare-earth metal heavy-fermion compounds; interfaces of electric-double-layer transistors; graphene and atomic sheets of transition metal dichalcogenide; iron selenide and organic conductors on oxide and metal surfaces, respectively. Unique phenomena arising from the ultimate wo dimensionality of the system and the physics behind them are discussed.

2017 *Supercond. Sci. Technol.* **30** 013002



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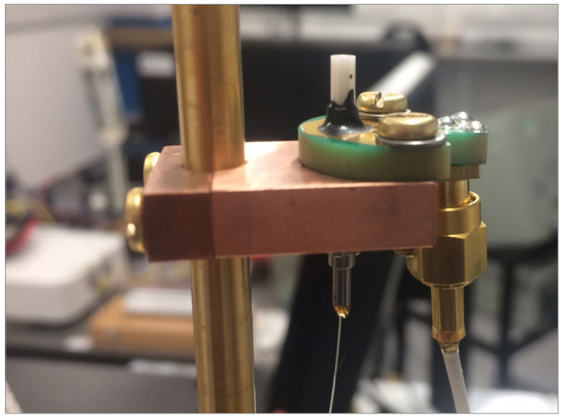
A miniaturized 4 K platform for superconducting infrared photon counting detectors

Nathan R Gemmell, Matthew Hills, Tom Bradshaw, Tom Rawlings, Ben Green, Robert M Heath, Konstantinos Tsimvrakidis, Sergiy Dobrovolskiy, Val Zwiller, Sander N Dorenbos, Martin Crook and Robert H Hadfield

Abstract

We report on a miniaturized platform for superconducting infrared photon counting detectors. We have implemented a fibre-coupled superconducting nanowire single photon detector in a Stirling/Joule–Thomson platform with a base temperature of 4.2 K. We have verified a cooling power of 4 mW at 4.7 K. We report 20% system detection efficiency at 1310 nm wavelength at a dark count rate of 1 kHz. We have carried out compelling application demonstrations in single photon depth metrology and singlet oxygen luminescence detection.

2017 *Supercond. Sci. Technol.* **30** 11LT01



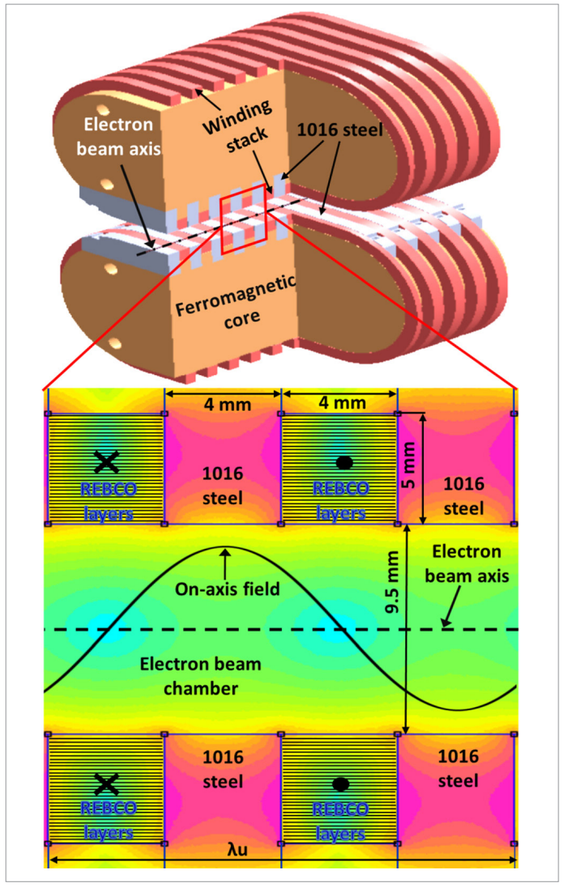
High-temperature superconducting undulator magnets

Ibrahim Kesgin, Matthew Kasa, Yury Ivanyushenkov and Ulrich Welp

Abstract

This paper presents test results on a prototype superconducting undulator magnet fabricated using 15% Zr-doped rare-earth barium copper oxide high temperature superconducting (HTS) tapes. On an 11-pole magnet we demonstrate an engineering current density, J_e, of more than 2.1 kA mm^{-2} at 4.2 K, a value that is 40% higher than reached in comparable devices wound with NbTi-wire, which is used in all currently operating superconducting undulators. A novel winding scheme enabling the continuous winding of tape-shaped conductors into the intricate undulator magnets as well as a partial interlayer insulation procedure were essential in reaching this advance in performance. Currently, there are rapid advances in the performance of HTS; therefore, achieving even higher current densities in an undulator structure or/and operating it at temperatures higher than 4.2 K will be possible, which would substantially simplify the cryogenic design and reduce overall costs.

2017 *Supercond. Sci. Technol.* **30** 04LT01



Magnetic levitation using a stack of high temperature superconducting tape annuli

A Patel, S Hahn, J Voccio, A Baskys, S C Hopkins and B A Glowacki

Abstract

Stacks of large width superconducting tape can carry persistent currents over similar length scales to bulk superconductors, therefore giving them potential for trapped field magnets and magnetic levitation. 46 mm wide high temperature superconducting tape has previously been cut into square annuli to create a 3.5 T persistent mode magnet. The same tape pieces were used here to form a composite bulk hollow cylinder with an inner bore of 26 mm. Magnetic levitation was achieved by field cooling with a pair of rare-earth magnets. This paper reports the axial levitation force properties of the stack of annuli, showing that the same axial forces expected for a uniform bulk cylinder of infinite J_c can be generated at 20 K. Levitation forces up to 550 N were measured between the rare-earth magnets and stack. Finite element modelling in COMSOL Multiphysics using the H-formulation was also performed including a full critical state model for induced currents, with temperature and field dependent properties as well as the influence of the ferromagnetic substrate which enhances the force. Spark erosion was used for the first time to machine the stack of tapes proving that large stacks can be easily machined to high geometric tolerance. The stack geometry tested is a possible candidate for a rotary superconducting bearing.

2017 *Supercond. Sci. Technol.* **30** 024007

Unprecedented quality factors at accelerating gradients up to 45 MVm^{-1} in niobium superconducting resonators via low temperature nitrogen infusion

A Grassellino, A Romanenko, Y Trenikhina, M Checchin, M Martinello, O S Melnychuk, S Chandrasekaran, D A Sergatskov, S Posen, A C Crawford, S Aderhold and D Bice

Abstract

We report the finding of new surface treatments that permits one to manipulate the niobium resonator nitrogen content in the first few nanometers in a controlled way, and the resonator fundamental Mattis–Bardeen surface resistance and residual resistance accordingly. In particular, we find surface 'infusion' conditions that systematically (a) increase the quality factor of these 1.3 GHz superconducting radio frequency (SRF) bulk niobium resonators, up to very high gradients; (b) increase the achievable accelerating gradient of the cavity compared to its own baseline with state-of-the-art surface processing. Cavities subject to the new surface process have more than two times the state-of-the-art Q at 2 K for accelerating fields >35 MVm^{-1}. Moreover, very high accelerating gradients ~45 MVm^{-1} are repeatedly reached, which correspond to peak magnetic surface fields of 190 mT, among the highest measured for bulk niobium cavities. These findings open the opportunity to tailor the surface impurity content distribution to maximize performance in Q and gradients, and have therefore very important implications on future performance and cost of SRF based accelerators. They also help deepen the understanding of the physics of the RF niobium cavity surface.

2017 *Supercond. Sci. Technol.* **30** 094004

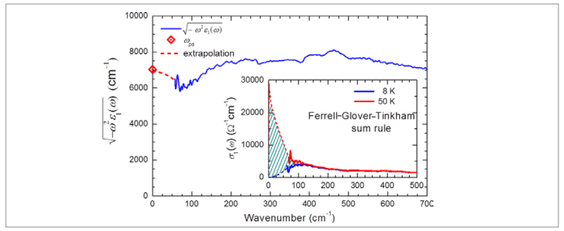
Structural, electro-magnetic, and optical properties of Ba(Fe,Ni)$_2$As$_2$ single-crystal thin film

Sejun Yoon, Yu-Seong Seo, Seokbae Lee, Jeremy D Weiss, Jianyi Jiang, MyeongJun Oh, Jongmin Lee, Sehun Seo, Youn Jung Jo, Eric E Hellstrom, Jungseek Hwang and Sanghan Lee

Abstract

We investigated the superconducting transition temperature (T_c), critical current density (J_c) and optical properties of optimally doped Ba(Fe$_{0.95}$Ni$_{0.05}$)$_2$As$_2$ (Ni-Ba122) single-crystalline epitaxial thin films grown by pulsed laser deposition for the first time. The T_c at zero resistivity was about 20.5 K and the J_c at self-field and 4.2 K was 2.8 MA cm^{-2} calculated by the Bean model. The superconducting properties such as T_c and J_c of thin films are comparable to those of bulk single-crystal samples. The superfluid plasma frequency ($\lambda_{p,S}$) of Ni-Ba122 thin film is ~7033 cm^{-1} obtained by optical spectroscopic technique. Based on this plasma frequency, we obtained the London penetration depth (λ_L), ~226 nm at 8 K, which is comparable to those of optimally Co- and K-doped $BaFe_2As_2$ single crystals.

2017 *Supercond. Sci. Technol.* **30** 035001



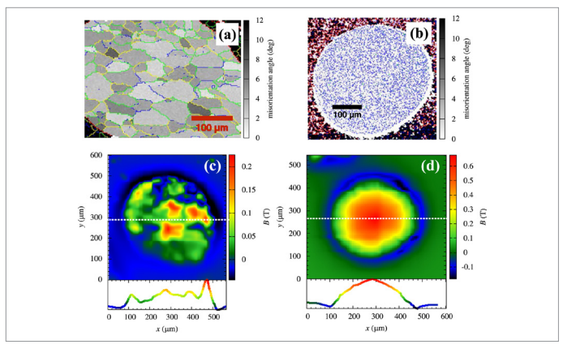
Magnetic granularity in pulsed laser deposited YBCO films on technical templates at 5 K

M Lao, J Hecher, P Pahlke, M Sieger, R Hühne and M Eisterer

Abstract

The manifestation of granularity in the superconducting properties of pulsed laser deposited YBCO films on commercially available metallic templates was investigated by scanning Hall probe microscopy at 5 K and was related to local orientation mapping of the YBCO layer. The YBCO films on stainless steel templates with a textured buffer layer of yttrium stabilized ZrO_2 grown by alternating beam assisted deposition have a mean grain size of less than 1μm with a sharp texture. This results in a homogeneous trapped field profile and spatial distribution of the current density. On the other hand, YBCO films on biaxially textured NiW substrates show magnetic granularity that persists down to a temperature of 5 K and up to an applied magnetic field of 4 T. The origin of the granular field profile is directly correlated to the microstructural properties of the YBCO layer adopted from the granular NiW substrate which leads to a spatially inhomogeneous current density. Grain-to-grain in-plane tilts lead to grain boundaries that obstruct the current while out-of-plane tilts mainly affect the grain properties, resulting in areas with low J_c. Hence, not all grain boundaries cause detrimental effects on J_c since the orientation of individual NiW grains also contributes to observed inhomogeneity and granularity.

2017 *Supercond. Sci. Technol.* **30** 104003



Development of a persistent superconducting joint between Bi-2212/Ag-alloy multifilamentary round wires

Peng Chen, Ulf P Trociewitz, Daniel S Davis, Ernesto S Bosque, David K Hilton, Youngjae Kim, Dmytro V Abraimov, William L Starch, Jianyi Jiang, Eric E Hellstrom and David C Larbalestier

Abstract

Superconducting joints are one of the key components needed to make Ag-alloy clad $Bi_2Sr_2CaCu_2O_{8+x}$ (Bi-2212) superconducting round wire (RW) successful for high-field, high-homogeneity magnet applications, especially for nuclear magnetic resonance magnets in which persistent current mode operation is highly desired. In this study, a procedure for fabricating superconducting joints between Bi-2212 RWs during coil reaction was developed. Melting temperatures of Bi-2212 powder with different amounts of Ag addition were investigated by differential thermal analysis so as to provide information for selecting the proper joint matrix. Test joints of 1.3 mm dia. wires heat treated in 1 bar flowing oxygen using the typical partial melt Bi-2212 heat treatment (HT) had transport critical currents I_c of ~900 A at 4.2 K and self-field, decreasing to ~480 A at 14 T evaluated at 0.1 μV cm^{-1} at 4.2 K. Compared to the I_c of the open-ended short conductor samples with identical 1 bar HT, the I_c values of the superconducting joint are ~20% smaller than that of conductor samples measured in parallel field but ~20% larger than conductor samples measured in perpendicular field. Microstructures examined by scanning electron microscopy clearly showed the formation of a superconducting Bi-2212 interface between the two Bi-2212 RWs. Furthermore, a Bi-2212 RW closed-loop solenoid with a superconducting joint heat treated in 1 bar flowing oxygen showed an estimated joint resistance below 5×10^{-12} Ω based on its field decay rate. This value is sufficiently low to demonstrate the potential for persistent operation of large inductance Bi-2212 coils.

2017 *Supercond. Sci. Technol.* **30** 025020

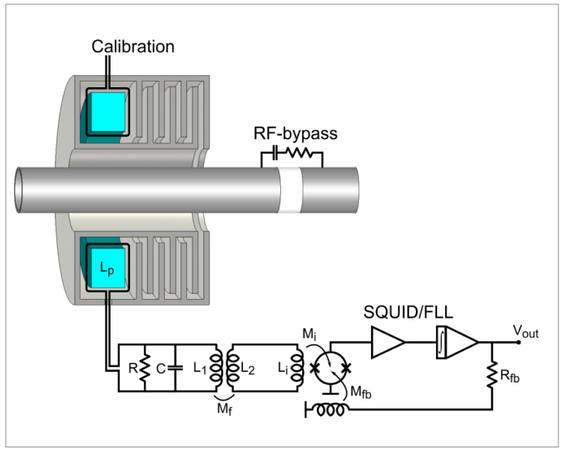
Non-perturbative measurement of low-intensity charged particle beams

M Fernandes, R Geithner, J Golm, R Neubert, M Schwickert, T Stöhlker, J Tan and C P Welsch

Abstract

Non-perturbative measurements of low-intensity charged particle beams are particularly challenging to beam diagnostics due to the low amplitude of the induced electromagnetic fields. In the low-energy antiproton decelerator (AD) and the future extra low energy antiproton rings at CERN, an absolute measurement of the beam intensity is essential to monitor the operation efficiency. Superconducting quantum interference device (SQUID) based cryogenic current comparators (CCC) have been used for measuring slow charged beams in the nA range, showing a very good current resolution. But these were unable to measure fast bunched beams, due to the slew-rate limitation of SQUID devices and presented a strong susceptibility to external perturbations. Here, we present a CCC system developed for the AD machine, which was optimised in terms of its current resolution, system stability, ability to cope with short bunched beams, and immunity to mechanical vibrations. This paper presents the monitor design and the first results from measurements with a low energy antiproton beam obtained in the AD in 2015. These are the first CCC beam current measurements ever performed in a synchrotron machine with both coasting and short bunched beams. It is shown that the system is able to stably measure the AD beam throughout the entire cycle, with a current resolution of 30 nA.

2017 *Supercond. Sci. Technol.* **30** 015001



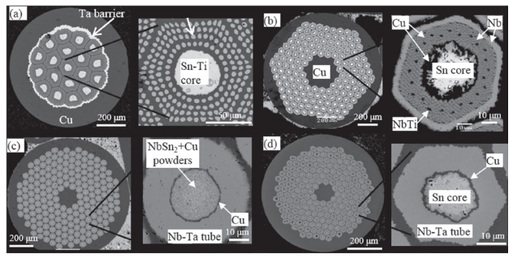
A review and prospects for Nb_3Sn superconductor development

Xingchen Xu

Abstract

Nb_3Sn superconductors have significant applications in constructing high-field (>10 T) magnets. This article briefly reviews development of Nb_3Sn superconductor and proposes prospects for further improvement. It is shown that significant improvement of critical current density (J_c) is needed for future accelerator magnets. After a brief review of the development of Nb_3Sn superconductors, the factors controlling J_c are summarized and correlated with their microstructure and chemistry. The non-matrix J_c of Nb_3Sn conductors is mainly determined by three factors: the fraction of current-carrying Nb_3Sn phase in the non-matrix area, the upper critical field B_{c2}, and the flux line pinning capacity. Then prospects to improve the three factors are discussed respectively. An analytic model was developed to show how the ratios of precursors determine the phase fractions after heat treatment, based on which it is predicted that the limit of current-carrying Nb_3Sn fraction in subelements is ~65%. Then, since B_{c2} is largely determined by the Nb_3Sn stoichiometry, a thermodynamic/kinetic theory is presented to show what essentially determines the Sn content of Nb_3Sn conductors. This theory explains the influences of Sn sources and Ti addition on stoichiometry and growth rate of Nb_3Sn layers. Next, to improve flux pinning, previous efforts in this community to introduce additional pinning centers to Nb_3Sn wires are reviewed, and an internal oxidation technique is described. Finally, prospects for further improvement of non-matrix J_c of Nb_3Sn conductors are discussed, and it is seen that the only opportunity for further significantly improving J_c lies in improving flux pinning.

2017 *Supercond. Sci. Technol.* **30** 093001



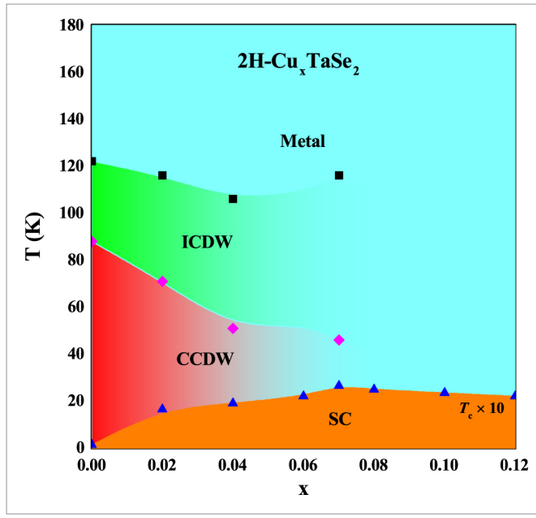
Significant enhancement of superconductivity in copper-doped 2H-$TaSe_2$

X C Li, M H Zhou, L H Yang and C Dong

Abstract

A series of Cu_xTaSe_2 ($0 \le x \le 0.12$) samples were prepared and characterized via x-ray diffraction, magnetization, resistivity, and heat capacity measurements. We found that the charge density wave phases in 2H-Cu_xTaSe_2 are noticeably suppressed and the superconducting critical temperatures T_c are significantly enhanced from 0.14 K for pure $TaSe_2$ to about 2 K in the Cu-doped samples. The maximum T_c of 2.7 K was obtained in the optimally doped sample with $x = 0.07$. The crystal structure of the $Cu_{0.07}TaSe_2$ was refined by the Rietveld method. Magnetic measurements revealed that $Cu_{0.07}TaSe_2$ is a bulk superconductor with upper critical field H_{c2} (0) of 4.41 T. Analysis of specific heat data shows that the effective electron–phonon coupling and density of states at the Fermi level are enhanced in the Cu-doped samples. We present an electronic phase diagram for the 2H-Cu x $TaSe_2$ system.

2017 *Supercond. Sci. Technol.* **30** 125001



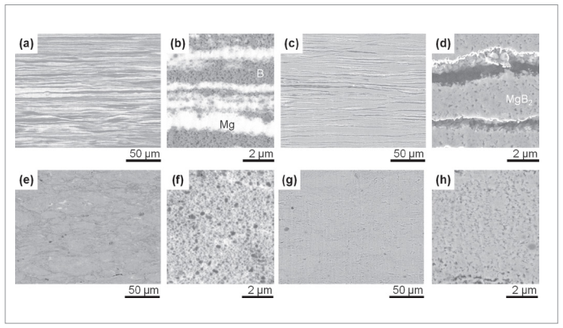
High-performance dense MgB_2 superconducting wire fabricated from mechanically milled powder

Motomune Kodama, Takaaki Suzuki, Hideki Tanaka, Kenji Okishiro, Kazutaka Okamoto, Gen Nishijima, Akiyoshi Matsumoto, Akiyasu Yamamoto, Jun-ichi Shimoyama and Kohji Kishio

Abstract

Owing to the relatively high critical temperature and the low manufacturing cost, MgB_2 superconducting wires are promising for liquid helium-free superconducting applications. Today, commercially available MgB_2 wires are manufactured by either an in situ or *ex situ* powder-in-tube process, the *in situ* process being more effective to obtain high critical current density. In *in situ*-processed wires, however, the critical current density is seriously suppressed by the high porosity of MgB_2 filaments. To resolve this problem, we propose an innovative method of using precursor powder prepared by mechanical milling of magnesium, boron, and coronene powders. This precursor powder has a metal–matrix–composite structure, in which boron particles are dispersed in a magnesium matrix. The plastic deformation of the precursor powder through wire processing leads to compact packing, and a dense MgB_2 filament is generated after heat treatment. As a result, the limitation of critical current density that occurs for the typical *in situ* process is overcome, and the practical critical current density of 10^3 A mm^{-2} is obtained at 10 K and 6.1 T, at 15 K and 4.8 T, and at 20 K and 3.3 T.

2017 *Supercond. Sci. Technol.* **30** 044006



Conductors for commercial MRI magnets beyond NbTi: requirements and challenges

Michael Parizh, Yuri Lvovsky and Michael Sumption

Abstract

Magnetic resonance imaging (MRI), a powerful medical diagnostic tool, is the largest commercial application of superconductivity. The superconducting magnet is the largest and most expensive component of an MRI system. The magnet configuration is determined by competing requirements including optimized functional performance, patient comfort, ease of siting in a hospital environment, minimum acquisition and lifecycle cost including service. In this paper, we analyze conductor requirements for commercial MRI magnets beyond traditional NbTi conductors, while avoiding links to a particular magnet configuration or design decisions. Potential conductor candidates include MgB_2, ReBCO and BSCCO options. The analysis shows that no MRI-ready non-NbTi conductor is commercially available at the moment. For some conductors, MRI specifications will be difficult to achieve in principle. For others, cost is a key barrier. In some cases, the prospects for developing an MRI-ready conductor are more favorable, but significant developments are still needed. The key needs include the development of, or significant improvements in: (a) conductors specifically designed for MRI applications, with form-fit-and-function readily integratable into the present MRI magnet technology with minimum modifications. Preferably, similar conductors should be available from multiple vendors; (b) conductors with improved quench characteristics, i.e. the ability to carry significant current without damage while in the resistive state; (c) insulation which is compatible with manufacturing and refrigeration technologies; (d) dramatic increases in production and long-length quality control, including large-volume conductor manufacturing technology. *In-situ* MgB_2 is, perhaps, the closest to meeting commercial and technical requirements to become suitable for commercial MRI. Conductor technology is an important, but not the only, issue in introduction of HTS/MgB_2 conductor into commercial MRI magnets. These new conductors, even when they meet the above requirements, will likely require numerous modifications and developments in the associated magnet technology.

2017 *Supercond. Sci. Technol.* **30** 014007

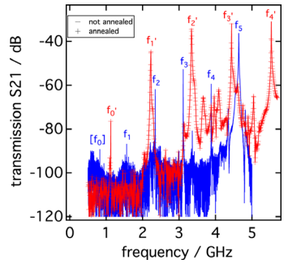
Aluminium-oxide wires for superconducting high kinetic inductance circuits

H Rotzinger, S T Skacel, M Pfirrmann, J N Voss, J Münzberg, S Probst, P Bushev, M P Weides, A V Ustinov and J E Mooij

Abstract

We investigate thin films of conducting aluminium-oxide, also known as granular aluminium, as a material for superconducting high quality, high kinetic inductance circuits. The films are deposited by an optimised reactive DC magnetron sputter process and characterised using microwave measurement techniques at milli-Kelvin temperatures. We show that, by precise control of the reactive sputter conditions, a high room temperature sheet resistance and therefore high kinetic inductance at low temperatures can be obtained. For a coplanar waveguide resonator with 1.5 kΩ sheet resistance and a kinetic inductance fraction close to unity, we measure a quality factor in the order of 700 000 at 20 mK. Furthermore, we observe a sheet resistance reduction by gentle heat treatment in air. This behaviour is exploited to study the kinetic inductance change using the microwave response of a coplanar wave guide resonator. We find the correlation between the kinetic inductance and the sheet resistance to be in good agreement with theoretical expectations.

2017 *Supercond. Sci. Technol.* **30** 025002



Design considerations and experimental results for MRI systems using HTS magnets

Ben Parkinson

Abstract

An increasing number of magnetic resonance imaging (MRI) systems using high temperature superconductors (HTS) magnets have been designed and constructed, with detailed results of their performance now available. Features of REBCO and BSCCO conductors are described as they pertain to use in high homogeneity magnets, with emphasis placed on the practical use of these conductors in magnets. Methods of coil winding are discussed, in particular the differences between pancake and layer winding techniques. Design considerations for HTS magnets are presented in light of the difficulties presented by quench in these magnets, but also in terms of the features of HTS magnets afforded by their high operating temperatures, namely robust cryogen free operation and the potential to use unshielded gradient coils. Drawing on two example MRI systems, namely a 3 T BSCCO brain imaging magnet developed in Japan and a 1.5 T REBCO orthopaedic imaging system developed in New Zealand, the report details real-world stability and homogeneity of HTS-MRI systems, in particular with regards to the screening current effects observed in these systems. It is concluded that, apart from conductor cost, there are currently no technical obstacles to use of HTS-MRI systems.

2017 *Supercond. Sci. Technol.* **30** 014009

Multi-scale model of resistive-type superconducting fault current limiters based on 2G HTS coated conductors

Charles-Henri Bonnard, Frédéric Sirois, Christian Lacroix and Gaëtan Didier

Abstract

In order to plan the integration of superconducting fault current limiters (SFCLs) in power systems, accurate models of SFCLs must be made available in commercial power system transient simulators. In this context, we developed such a model for the EMTP-RV software package, a power system transient simulator widely used by power utilities. The model can be used with any resistive-type SFCL (rSFCL) made of high temperature superconductor (HTS) tapes, which are discretized in 'electro-thermal elements'. Those elements consist solely of electric circuit components, and are used to represent portions of tape of various sizes and dimensions (a 'multi-scale' approach). Both the electrical and thermal behaviors of the tape are modeled, including interfacial effects, nonlinear properties of materials and heat transfer to the surrounding environment. Such a multi-scale model can simulate accurately both the local quench dynamics of HTS tapes (microscopic scale) and the global impact of the rSFCL on the power system (macroscopic/system scale). In this paper, the model is used to compute phenomena such as propagation velocity of a hot spot and heat diffusion through the thickness of the tape. Results were verified by comparing EMTP-RV results with finite element simulations. In addition to the development of the multi-scale model itself, which is the major contribution of this paper, the use of the model allowed us to determine the conditions of validity of the commonly used 'homogenization' of the thermal properties across the tape thickness. Indeed, when the current flowing into the rSFCL is slightly above its critical current I_c (and up to $2I_c$), very important errors in the power waveforms arise, leading to potentially wrong decisions of protection systems. Homogenized thermal models should thus be used with great care in practice.

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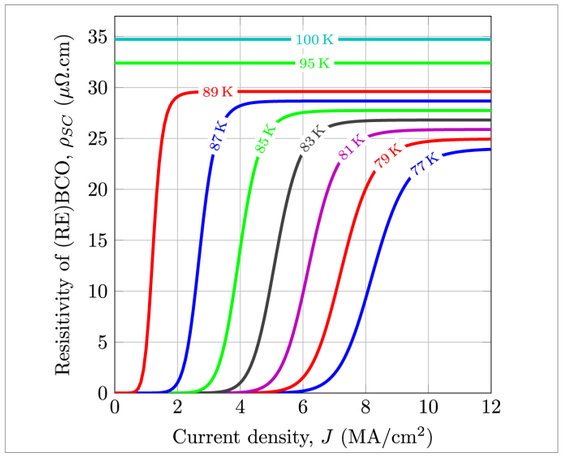

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Simulation and experiments of stacks of high temperature superconducting coated conductors magnetized by pulsed field magnetization with multi-pulse technique

Shengnan Zou, Víctor M R Zermeño, A Baskys, A Patel, Francesco Grilli and B A Glowacki

Abstract

High temperature superconducting bulks or stacks of coated conductors (CCs) can be magnetized to become trapped field magnets (TFMs). The magnetic fields of such TFMs can break the limitation of conventional magnets (<2 T), so they show potential for improving the performance of many electrical applications that use permanent magnets like rotating machines. Towards practical or commercial use of TFMs, effective *in situ* magnetization is one of the key issues. The pulsed field magnetization (PFM) is among the most promising magnetization methods in virtue of its compactness, mobility and low cost. However, due to the heat generation during the magnetization, the trapped field and flux acquired by PFM usually cannot achieve the full potential of a sample (acquired by the field cooling or zero field cooling method). The multi-pulse technique was found to effectively improve the trapped field by PFM in practice. In this work, a systematic study on the PFM with successive pulses is presented. A 2D electromagnetic-thermal coupled model with comprehensive temperature dependent parameters is used to simulate a stack of CCs magnetized by successive magnetic pulses. An overall picture is built to show how the trapped field and flux evolve with different pulse sequences and the evolution patterns are analyzed. Based on the discussion, an operable magnetization strategy of PFM with successive pulses is suggested to provide more trapped field and flux. Finally, experimental results of a stack of CCs magnetized by typical pulse sequences are presented for demonstration.

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Characterisation of amorphous molybdenum silicide (MoSi) superconducting thin films and nanowires

Archan Banerjee, Luke J Baker, Alastair Doye, Magnus Nord, Robert M Heath, Kleanthis Erotokritou, David Bosworth, Zoe H Barber, Ian MacLaren and Robert H Hadfield

Abstract

We report on the optimisation of amorphous molybdenum silicide thin film growth for superconducting nanowire single-photon detector (SNSPD) applications. Molybdenum silicide was deposited via co-sputtering from Mo and Si targets in an Ar atmosphere. The superconducting transition temperature (T_c) and sheet resistance (R_s) were measured as a function of thickness and compared to several theoretical models for disordered superconducting films. Superconducting and optical properties of amorphous materials are very sensitive to short- (up to 1nm) and medium-range order (~1–3 nm) in the atomic structure. Fluctuation electron microscopy studies showed that the films assumed an A15-like medium-range order. Electron energy loss spectroscopy indicates that the film stoichiometry was close to $Mo_{83}Si_{17}$, which is consistent with reports that many other A15 structures with the nominal formula A_3B show a significant non-stoichiometry with *A:B* > 3:1. Optical properties from ultraviolet (270 nm) to infrared (2200 nm) wavelengths were measured via spectroscopic ellipsometry for 5 nm thick MoSi films indicating high long wavelength absorption. We also measured the current density as a function of temperature for nanowires patterned from a 10 nm thick MoSi film. The current density at 3.6 K is 3.6 × 10^5 A cm^{-2} for the widest wire studied (2003 nm), falling to 2 × 10^5 A cm^{-2} for the narrowest (173 nm). This investigation confirms the excellent suitability of MoSi for SNSPD applications and gives fresh insight into the properties of the underlying materials.

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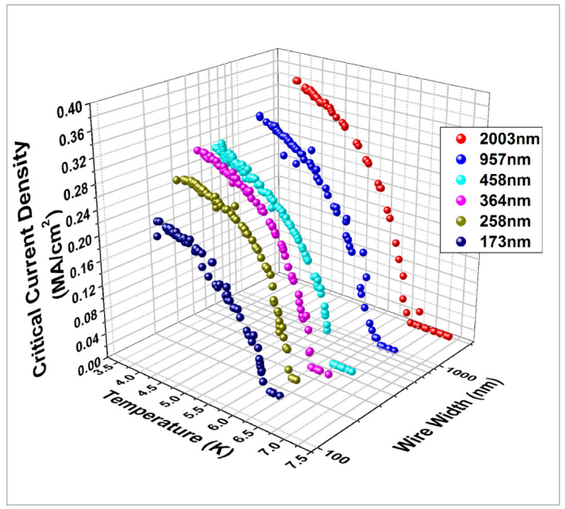

Ferromagnetic resonance with long Josephson junction

I A Golovchanskiy, N N Abramov, V S Stolyarov, O V Emelyanova, A A Golubov, A V Ustinov and V V Ryazanov

Abstract

In this work we propose a hybrid device based on a long Josephson junction (JJ) coupled inductively to an external ferromagnetic (FM) layer. The long JJ in a zero-field operation mode induces a localized AC magnetic field in the FM layer and enables a synchronized magnetostatic standing wave. The magnetostatic wave induces additional dissipation for soliton propagation in the junction and also enables a phase locking (resonant soliton synchronization) at a frequency of natural ferromagnetic resonance. The later manifests itself as an additional constant voltage step on the current–voltage characteristics at the corresponding voltage. The proposed device allows to study magnetization dynamics of individual micro-scaled FM samples using just DC technique, and also it provides additional phase locking frequency in the junction, determined exclusively by characteristics of the ferromagnet.

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