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Organisations

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**Wind Energy Systems**
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**Wind Turbines**
24/12/2015 → 05/02/2016 Former
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**Publications:**

**Comparison of Levelized Cost of Energy of superconducting direct drive generators for a 10 MW offshore wind turbine**
A method for comparing the Levelized Cost of Energy (LCoE) of different superconducting drive trains is introduced. The properties of a 10 MW MgB$_2$ superconducting direct drive generator are presented in terms weight scaled to a turbine with a rotor diameter up of 280 m and the cost break down of the nacelle components. The partial load efficiency of the generator is evaluated for a constant cooling power of 0, 50 kW and 100 kW and the annual energy production is used to determine the impact on Levelized Cost of Energy.

**General information**
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology
Number of pages: 5
Publication date: 2018
Main Research Area: Technical/natural sciences

**Publication information**
Journal: IEEE Transactions on Applied Superconductivity
Volume: 28
Issue number: 4
Article number: 5208205
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
Decomposing the Bragg glass and the peak effect in a Type-II superconductor

Adding impurities or defects destroys crystalline order. Occasionally, however, extraordinary behaviour emerges that cannot be explained by perturbing the ordered state. One example is the Kondo effect, where magnetic impurities in
metals drastically alter the temperature dependence of resistivity. In Type-II superconductors, disorder generally works to pin vortices, giving zero resistivity below a critical current \( j(c) \). However, peaks have been observed in the temperature and field dependences of \( j(c) \). This peak effect is difficult to explain in terms of an ordered Abrikosov vortex lattice. Here we test the widespread paradigm that an order-disorder transition of the vortex ensemble drives the peak effect. Using neutron scattering to probe the vortex order in superconducting vanadium, we uncover an order-disorder transition from a quasi-long-range-ordered phase to a vortex glass. The peak effect, however, is found to lie at higher fields and temperatures, in a region where thermal fluctuations of individual vortices become significant.
Fabrication of a Scaled MgB2 Racetrack Demonstrator Pole for a 10-MW Direct-Drive Wind Turbine Generator

Field windings made of MgB2 wires or tapes are considered for their potential to reduce volume, weight, and cost of large offshore wind turbine generators. To gain experience of how to use this relatively new material in full-scale generators, tests of different winding methodologies and techniques are needed. In this paper, we describe in detail the steps used to wind a racetrack coil with a length of 1 m and a width of 0.5 m out of 4.5 km of MgB2 superconducting tape. The width corresponds to a full-scale pole of a 10-MW generator, whereas the length of the straight section is shorter than the corresponding full-scale pole. The coil was built up of ten double pancake coils. Each double pancake coil was wet wound using a semiautomatic winding process, where Stycast 2850 was applied directly to the MgB2 tape without any other dedicated electrical insulation. The strengths and weaknesses of the winding process are discussed and compared to the dry-winding method.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, SINTEF, Norwegian University of Science and Technology
Authors: Magnusson, N. (Ekstern), Eliassen, J. C. (Ekstern), Abrahamsen, A. B. (Intern), Helleso, S. M. (Ekstern), Runde, M. (Ekstern), Nysveen, A. (Ekstern), Moslatt, L. (Ekstern), Bjerkli, J. (Ekstern), King, P. (Ekstern)
Number of pages: 5
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Applied Superconductivity
Volume: 28
Issue number: 4
Article number: 5207105
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.555 SNIP 1.274 CiteScore 1.11
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.368 SNIP 1.062 CiteScore 1.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.473 SNIP 1.065
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.447 SNIP 1.021
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Magnetoelastic phase diagram of TbNi$_2$B$_2$C

The magnetic phase diagram of the quaternary borocarbide TbNi$_2$B$_2$C is investigated by direct means and by studying magnetically induced modifications of the crystal structure. Detailed superconducting quantum interference device measurements reveal a complex phase diagram with five distinct magnetic phases. The phase boundaries are mapped out comprehensively. Synchrotron hard x-ray measurements in applied magnetic fields are employed to probe the magnetoelastic distortions throughout the phase diagram. The determination of the wave vectors of these field-induced lattice deformations suggests a range of commensurate spin-slip-type magnetic structures at low temperatures with wave vectors of the form $(q,0,0)$ with $q = 6/11$ and $5/9$. The proposed magnetic structures yield values of magnetization well in-line with observations. The scattering intensity due to the magnetoelastic deformations exhibits a drastic jump at the phase boundary at 1.3 T and low temperatures.
Optimal design of galvanic corrosion protection systems for offshore wind turbine support structures

The current work addresses a mass/cost optimization procedure for galvanic anode cathodic protection (GACP) systems based on both cathodic protection (CP) standards and numerical simulation. An approach is developed for optimizing the number and dimensions of the galvanic anodes, distributing the optimized anodes on the support structure, and finally evaluating the protective potential on the structure during the lifetime by calling the finite element (FE) software COMSOL. An algorithm based on Sequential Quadratic Programming (SQP) is used for optimizing the number and dimensions of the anodes. Both simplified and detailed models are suggested for calculating the protective potential on the structure. The simplified model is selected based on its advantages in terms of calculation time and compatibility with DNV standard data. A time-dependent FE model is employed to take into account the electrical isolation degradation of the structure coating as well as the mass reduction of the anodes during the CP lifetime.

The performance of the proposed optimization process is examined on a mono bucket inspired (with some simplifications)
by the Dogger Bank metrological mast in England. The optimized designs for different coating and anode types are
compared and the best designs in terms of both cost and protective potential during the lifetime are suggested. The
achieved results show that the proposed optimization procedure can reduce the cost of the CP system around 70%
compared to the original non-optimized CP design of the Dogger Bank metrological mast. Furthermore, evaluating
the time-evolution performance of the CP systems can reduce their lifetime uncertainty.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Sarhadi, A. (Intern), Abrahamsen, A. B. (Intern), Stolpe, M. (Intern)
Pages: 829-841
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: Corrosion
Volume: 74
Issue number: 7
ISSN (Print): 0010-9312
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.95 SJR 0.955 SNIP 1.376
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.02 SJR 1.075 SNIP 1.511
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.887 SNIP 1.52 CiteScore 1.61
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.488 SNIP 0.899 CiteScore 0.92
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.552 SNIP 1.349 CiteScore 0.77
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.482 SNIP 0.883 CiteScore 0.67
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.596 SNIP 1.438 CiteScore 1.03
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.681 SNIP 1.414
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.883 SNIP 1.554
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.803 SNIP 1.079
Scopus rating (2007): SJR 0.986 SNIP 1.195
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.881 SNIP 1.231
Scopus rating (2005): SJR 1.149 SNIP 1.408
Scopus rating (2004): SJR 1.121 SNIP 1.415
Scopus rating (2003): SJR 0.982 SNIP 1.76
Scopus rating (2002): SJR 1.139 SNIP 1.606
Scopus rating (2001): SJR 1.537 SNIP 1.81
Scopus rating (2000): SJR 0.969 SNIP 2.141
Two level undercut-profile substrate-based filamentary coated conductors produced using metal organic chemical vapor deposition

The two level undercut-profile substrate (2LUPS) has been introduced as a concept for subdividing rare-earth-Ba$_2$Cu$_3$O$_7$ (REBCO) coated conductors (CC) into narrow filaments which reduces the AC losses and improves field stability for DC magnets. The 2LUPS consists of two levels of plateaus connected by a wall with an undercut-profile, which enables a physical separation of the superconducting layer between the plateaus without reducing the effective width of the superconducting layer. In this study we report for the first time the results of fabrication and characterization of a filamentary CC produced in an industrial setup by SuperPower Inc. using ion beam assisted deposition and metal organic chemical vapor deposition (IBAD-MOCVD) on a 2LUPS substrate realized at the Technical University of Denmark (DTU), whereas previous studies discussed the fabrication using alternating beam assisted deposition and pulsed laser deposition (ABAD-PLD). We also present Hall probe scanning measurements performed using a standard TAPESTAR® XL machine that is routinely employed for industrial critical current characterization of long length CCs. It clear that additional analysis of the measured field profiles are required when characterizing filamentary 2LUPS CC using a standard TAPESTAR® setting. Using FEM we calculated the expected magnetization response and we find a good agreement.

General information

State: Published
Number of pages: 5
Publication date: 2018
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Applied Superconductivity
Volume: 28
Issue number: 4
Article number: 6601705
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Effects of Armature Winding Segmentation with Multiple Converters on the Short Circuit Torque of 10-MW Superconducting Wind Turbine Generators

Superconducting synchronous generators (SCSGs) are drawing more attention in large direct-drive wind turbine applications. Despite low weight and compactness, the short circuit torque of an SCSG may be too high for wind turbine constructions due to a large magnetic air gap of an SCSG. This paper aims at assessing the effects of armature winding segmentation on reducing the short circuit torque of 10-MW SCSGs. A concept of armature winding segmentation with multiple power electronic converters is presented. Four SCSG designs using different topologies are examined. Results show that armature winding segmentation effectively reduce the short circuit torque in all the four SCSG designs when one segment is shorted at the terminal.
Wind turbine, Armature winding segmentation, Short circuit, Superconducting generator, Topology, Torque
Hydrogen Decrepitation Press-Less Process Recycling of NdFeB sintered magnets

A Hydrogen Decrepitation Press-Less Process (HD-PLP) recycling method for recycling of anisotropic NdFeB magnets is demonstrated. The method combines hydrogen decrepitation (HD) disintegration of the initial magnet, powder sieving and the Press-Less Process (PLP), where hydride powder is sintered in a graphite mold. Coercivities up to 534 kA/m were obtained in porous samples based on powder size $d < 100 \mu m$. Adding a ball milling step resulted in full density isotropic magnets for $d > 100 \mu m$. The coercivity reached $H_{ci} = 957$ kA/m being 86% of the original N48M material without addition of rare earth elements.

General information
State: Published
Authors: Xia, M. (Intern), Abrahamsen, A. B. (Intern), Bahl, C. (Intern), Veluri, B. (Ekstern), Søegaard, A. I. (Ekstern), Bøjsøe, P. (Ekstern)
Pages: 55-61
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Magnetism and Magnetic Materials
Volume: 441
ISSN (Print): 0304-8853
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SJR 0.786 SNIP 1.349 CiteScore 2.97
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 0.699 SNIP 1.181
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.73 SNIP 1.296 CiteScore 2.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.815 SNIP 1.423 CiteScore 2.07
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.801 SNIP 1.385 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.928 SNIP 1.294 CiteScore 1.95
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.07 SNIP 1.275 CiteScore 1.84
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.936 SNIP 0.987
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Optimization and comparison of superconducting generator topologies for a 10 MW wind turbine application

A direct-drive superconducting generator (DDSCG) is proposed for 10 MW wind turbines in the INNWIND.EU project. To fit the generator into the "king-pin" conceptual nacelle design, the generator structure with inner stationary superconducting (SC) field winding and outer rotating copper armature winding is investigated in the first research phase. Since the cost is an important performance indicator for this application, this paper presents a method to minimize the active material cost of the "king-pin" fitted DDSCG. In this method a relatively fast optimization program is developed with 2D non-linear finite element models. By implementing this method, three typical superconducting generator topologies are compared in terms of the active material cost and mass, the synchronous reactance and the phase resistance. The optimization method and the comparison results provide the DDSCG designers with a guideline for selecting a suitable machine topology.

General information
State: Published
Authors: Liu, D. (Ekstern), Polinder, H. (Ekstern), Abrahamsen, A. B. (Intern), Stehouwer, E. (Ekstern), Hendriks, B. (Ekstern), Magnusson, N. (Ekstern)
Pages: 191-202
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: The International Journal of Applied Electromagnetics and Mechanics
Volume: 53
Issue number: Suppl. 2
ISSN (Print): 1383-5416
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
This paper aims at assessing the potential of partially superconducting generators for 10 MW direct-drive wind turbines by investigating their performance for a very wide range of excitation currents. Performance indicators such as shear stress and efficiency and other generator characteristics are compared for 12 different generator topologies. To be sufficiently attractive, superconducting generators must have significant advantages over permanent magnet direct-drive generators, which typically have shear stresses of the order of 53 kPa and efficiencies of 96%. Therefore, we investigate what excitation is required to obtain a doubled shear stress and an efficiency of 98%. To achieve this, the different topologies require a range of excitation from 200 to 550 kAt (ampere-turns) with a low armature current density of 2 A/mm(2). The more iron that is used in the core of these topologies, the easier they achieve this performance. By examining the maximum magnetic flux density at the location of the superconducting field winding, feasible superconductors can be chosen according to their engineering current density capabilities. It is found that high- and low-temperature superconductors can meet the performance criteria for many of the topologies. MgB2 superconductors are feasible for the fully iron-cored topology with salient poles but need cooling down to 10 K.

Potential of Partially Superconducting Generators for Large Direct-Drive Wind Turbines
This paper aims at assessing the potential of partially superconducting generators for 10 MW direct-drive wind turbines by investigating their performance for a very wide range of excitation currents. Performance indicators such as shear stress and efficiency and other generator characteristics are compared for 12 different generator topologies. To be sufficiently attractive, superconducting generators must have significant advantages over permanent magnet direct-drive generators, which typically have shear stresses of the order of 53 kPa and efficiencies of 96%. Therefore, we investigate what excitation is required to obtain a doubled shear stress and an efficiency of 98%. To achieve this, the different topologies require a range of excitation from 200 to 550 kAt (ampere-turns) with a low armature current density of 2 A/mm(2). The more iron that is used in the core of these topologies, the easier they achieve this performance. By examining the maximum magnetic flux density at the location of the superconducting field winding, feasible superconductors can be chosen according to their engineering current density capabilities. It is found that high- and low-temperature superconductors can meet the performance criteria for many of the topologies. MgB2 superconductors are feasible for the fully iron-cored topology with salient poles but need cooling down to 10 K.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design, Delft University of Technology
Authors: Liu, D. (Ekstern), Polinder, H. (Ekstern), Abrahamsen, A. B. (Intern), Ferreira, J. A. (Ekstern)
Number of pages: 11
The Effect of Nano-TiC Addition on Sintered Nd-Fe-B Permanent Magnets

This paper addresses the effect of nano-TiC addition on sintered Nd-Fe-B permanent magnets. TiC nanoparticles were added to sintered Nd-Fe-B magnets with a specific aim to improve the Curie temperature and thermal stability. A standard powder metallurgy route was adopted to prepare the magnets. It was found that introducing nano-TiC prior to jet milling was effective as the nanoparticles dispersed in the final alloy, concentrating in the neodymium-rich phase of the magnets. Magnets with optimal properties were obtained with the addition of 1 wt% TiC nanoparticles. The hysteresis loop for such magnets showed an improved shape and VSM analysis a coercivity value of 1188 kA/m, a remanence value of 0.96 T and a maximum energy product of 132 kJ/m³. The maximum working point and the Curie temperature of the developed magnets were 373 K and 623 K respectively.

General information
State: Published
Organisations: Department of Energy Conversion and Storage, Electrofunctional materials, Department of Wind Energy, Wind Turbine Structures and Component Design, Tallinn University of Technology, National Institute of Chemical Physics and Biophysics
Authors: Mural, Z. (Ekstern), Kollo, L. (Ekstern), Xia, M. (Intern), Bahl, C. (Intern), Abrahamsen, A. B. (Intern), Neves Bez, H. (Intern), Link, J. (Ekstern), Veinthal, R. (Ekstern)
Number of pages: 11
Pages: 23–28
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Magnetism and Magnetic Materials
Volume: 429
ISSN (Print): 0304-8853
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SJR 0.786 SNIP 1.349 CiteScore 2.97
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 0.699 SNIP 1.181
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.73 SNIP 1.296 CiteScore 2.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.815 SNIP 1.423 CiteScore 2.07
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.801 SNIP 1.385 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.928 SNIP 1.294 CiteScore 1.95
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.07 SNIP 1.275 CiteScore 1.84
The influence of carbon and oxygen on the magnetic characteristics of press-less sintered NdFeB magnets

The Pressless Process (PLP) was adopted to manufacture NdFeB sintered magnets, where the investigations on carbon and oxygen residues from heptane milling liquid media and graphite crucibles used for sintering were quantified to evaluate the influence on the magnetic characteristics. The carbon and oxygen content in the magnets produced from wet ball milling of strip cast flakes was found to be of the order 104 ppm and 4·104 ppm respectively, which resulted in soft magnetic behavior. However using jet milling the carbon and oxygen concentration were decreased by an order of magnitude resulting in coercivity of up to 829 kA/m. Thus the influence of the carbon from the graphite crucibles is small.

General information

State: Published
Authors: Xia, M. (Intern), Abrahamsen, A. B. (Intern), Bahl, C. (Intern), Veluri, B. (Ekstern), Seegaard, A. I. (Ekstern), Bøjssøe, P. (Ekstern), Millot, S. (Ekstern)
Number of pages: 5
Pages: 232-236
Publication date: 2017
Main Research Area: Technical/natural sciences

Publication information

Journal: Journal of Magnetism and Magnetic Materials
Volume: 422
ISSN (Print): 0304-8853
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SJR 0.786 SNIP 1.349 CiteScore 2.97
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 0.699 SNIP 1.181
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.73 SNIP 1.296 CiteScore 2.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.815 SNIP 1.423 CiteScore 2.07
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.801 SNIP 1.385 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.928 SNIP 1.294 CiteScore 1.95
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.07 SNIP 1.275 CiteScore 1.84
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.936 SNIP 0.987
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.844 SNIP 0.908
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.867 SNIP 0.903
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.711 SNIP 0.844
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.838 SNIP 0.882
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.699 SNIP 0.692
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.811 SNIP 1.044
Web of Science (2004): Indexed yes
Scopus rating (2003): SJR 1.051 SNIP 0.957
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.233 SNIP 1.143
Web of Science (2002): Indexed yes
Scopus rating (2001): SJR 1.209 SNIP 0.978
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.832 SNIP 0.936
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 0.875 SNIP 0.912

Original language: English
Carbon, NdFeB, Oxygen, Sintering, α-Fe
DOIs:
This paper aims at finding feasible electromagnetic designs of superconducting synchronous generators (SCSGs) for a 10-MW direct-drive wind turbine. Since a lower levelized cost of energy ($\text{LCoE}$) increases the feasibility of SCSGs in this application, 12 generator topologies are compared regarding their $\text{LCoE}$ in a simplified form of levelized equipment cost of energy ($\text{LCoE}_{\text{equip}}$). MgB$_2$ wires are employed in the field winding. Based on the current unit cost and critical current density capability of the MgB$_2$ wire at 20 K, the topologies with more iron have a much lower $\text{LCoE}_{\text{equip}}$ than the topologies with more nonmagnetic cores. The fully iron-cored topology with salient poles has the lowest $\text{LCoE}_{\text{equip}}$. Then a scenario study shows that the difference of $\text{LCoE}_{\text{equip}}$ between the topologies will become much smaller when the unit cost of the MgB$_2$ wire drops to a quarter and the current density capability of the MgB$_2$ wire increases to four times. Then the topologies with more nonmagnetic cores will become comparable to those with more iron. Aiming at a lower LCoE to increase the feasibility of SCSGs for large wind turbines, those topologies having the most iron in the core are the most promising for both now and the long term. If low weight is required, the topologies with more nonmagnetic cores should be considered.
Comparison of superconducting generators and permanent magnet generators for 10-MW direct-drive wind turbines

Large offshore direct-drive wind turbines of 10-MW power levels are being extensively proposed and studied because of a reduced cost of energy. Conventional permanent magnet generators currently dominating the direct-drive wind turbine market are still under consideration for such large wind turbines. In the meantime, superconducting generators (SCSGs) have been of particular interest to become a significant competitor because of their compactness and light weight. This paper compares the performance indicators of these two direct-drive generator types in the same 10-MW wind turbine under the same design and optimization method. Such comparisons will be interesting and insightful for commercialization of superconducting generators and for development of future wind energy industry, although SCSGs are still far from a high technology readiness level. The results show that the SCSGs may not be too expensive regarding capital cost of energy. If other major costs and reliability factors related to superconductivity are taken into consideration, however, the SCSGs may not be competitive yet at the moment.
Long-term research challenges in wind energy – a research agenda by the European Academy of Wind Energy

The European Academy of Wind Energy (eawe), representing universities and institutes with a significant wind energy programme in 14 countries, has discussed the long-term research challenges in wind energy. In contrast to research agendas addressing short- to medium-term research activities, this eawe document takes a longer-term perspective, addressing the scientific knowledge base that is required to develop wind energy beyond the applications of today and tomorrow. In other words, this long-term research agenda is driven by problems and curiosity, addressing basic research and fundamental knowledge in 11 research areas, ranging from physics and design to environmental and societal aspects. Because of the very nature of this initiative, this document does not intend to be permanent or complete. It shows the vision of the experts of the eawe, but other views may be possible. We sincerely hope that it will spur an even more intensive discussion worldwide within the wind energy community.

General information
State: Published
Organisations: Department of Wind Energy, Meteorology & Remote Sensing, Fluid Mechanics, Wind Turbine Structures and Component Design, Integration & Planning, Department of Management Engineering, Energy Economics and Regulation, Delft University of Technology, National Renewable Energy Laboratory, Durham University, University of Stuttgart, Wageningen IMARES, University of Oldenburg, Politecnico di Milano, Knowledge Centre Wind turbine Materials and Constructions, Centre for Renewable Energy Sources, Aalborg University, Norwegian University of Science and Technology, Royal Belgian Institute of Natural Sciences
Pages: 1-39
Publication date: 2016
Main Research Area: Technical/natural sciences

Publication information
Journal: Wind Energy Science
Volume: 1
ISSN (Print): 2366-7443
Original language: English
Electronic versions:
Long_term_research_challenges.pdf
DOIs:
10.5194/wes-1-1-2016
Links:
http://www.wind-energ-sci.net/1/1/2016/

Bibliographical note
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Source: PublicationPreSubmission
Source-ID: 120923997
Publication: Research - peer-review › Article in proceedings – Annual report year: 2017

New direct drive technologies of INNWIND.EU: Superconducting vs. Pseudo Direct Drive

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Abrahamsen, A. B. (Intern)
Number of pages: 13
Publication date: 2016

Publication information
Media of output: PowerPoint
Original language: English
Main Research Area: Technical/natural sciences
Ripple Field AC Losses in 10-MW Wind Turbine Generators With a MgB2 Superconducting Field Winding

Superconducting (SC) synchronous generators are proposed as a promising candidate for 10-20-MW direct-drive wind turbines because they can have low weights and small sizes. A common way of designing an SC machine is to use SC wires with high current-carrying capability in the dc field winding and the ac armature winding is made with copper conductors. In such generators, the dc field winding is exposed to ac magnetic field ripples due to space harmonics from the armature. In generator design phases, the ac loss caused by these ripple fields needs to be evaluated to avoid local overheating and an excessive cooling budget. To determine the applicability of different design solutions in terms of ac losses, this paper estimates the ac loss level of 10-MW wind generator designs employing a MgB2 SC field winding. The effects on ac losses are compared between nonmagnetic and ferromagnetic teeth with different numbers of slots per pole per phase. The necessity of an electromagnetic shield is then discussed based on the obtained loss levels. The results show that the total ac loss is so small that ferromagnetic teeth can be applied in the generator design without using an electromagnetic shield.
Variation of Extreme and Fatigue Design Loads on the Main Bearing of a Front Mounted Direct Drive System

The drivetrain of a 10 MW wind turbine has been designed as a direct drive transmission with a superconducting generator mounted in front of the hub and connected to the main frame through a King-pin stiff assembly by DNV-GL. The aeroelastic design loads of such an arrangement are evaluated based on the thrust and bending moments at the main bearing, both for ultimate design and in fatigue. It is found that the initial superconductor generator weight of 363 tons must be reduced by 25% in order not to result in higher extreme loads on main and yaw bearing than the reference 10 MW geared reference drive train. A weight reduction of 50% is needed in order to maintain main bearing fatigue damage equivalent to the reference drive train. Thus a target mass of front mounted superconducting direct drive generators is found to be between 183-272 tons.

General information
State: Published
Organisations: Department of Wind Energy, Wind Turbine Structures and Component Design
Authors: Abrahamsen, A. B. (Intern), Natarajan, A. (Intern)
Number of pages: 10
Publication date: 2016
Conference: The Science of Making Torque from Wind , Munich, Germany, 05/10/2016 - 05/10/2016
BFI conference series: European Academy of Wind Energy : The Science of Making Torque from Wind (5010078)
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 753
Article number: 112006
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Variation of Extreme and Fatigue Design Loads on the Main Bearing of a Front Mounted Direct Drive System

The drivetrain of a 10 MW wind turbine has been designed as a direct drive transmission with a superconducting generator mounted in front of the hub and connected to the main frame through a King-pin stiff assembly by DNV-GL. The aeroelastic design loads of such an arrangement are evaluated based on the thrust and bending moments at the main bearing, both for ultimate design and in fatigue. It is found that the initial superconductor generator weight of 363 tons must be reduced by 25% in order not to result in higher extreme loads on main and yaw bearing than the reference 10 MW geared reference drive train. A weight reduction of 50% is needed in order to maintain main bearing fatigue damage equivalent to the reference drive train. Thus a target mass of front mounted superconducting direct drive generators is found to be between 183-272 tons.
Comparison of 10 MW superconducting generator topologies for direct-drive wind turbines

Large wind turbines of 10 MW or higher power levels are desirable for reducing the cost of energy of offshore wind power conversion. Conventional wind generator systems will be costly if scaled up to 10 MW due to rather large size and weight. Direct drive superconducting generators have been proposed to address the problem with generator size, because the electrical machines with superconducting windings are capable of achieving a higher torque density of an electrical machine. However, the topology to be adopted for superconducting wind generators has not yet been settled, since the high magnetic field excitation allows for lightweight non-magnetic composite materials for machine cores instead of iron. A topology would probably not be a good option for an offshore wind turbine generator if it demands a far more expensive active material cost than others, even if it has other advantages such as light weight or small iron losses. This paper is to provide a preliminary quantitative comparison of 10 MW superconducting MgB2 generator topologies from the perspective of active material. The results show that iron-cored topologies have a cheaper active material and their sizes are relatively smaller than the others.
Design Aspects on Winding of an MgB₂ Superconducting Generator Coil

Generators based on superconducting rotor coils are considered for future large off-shore wind turbines for their low weight and compact design, and for their possibility to reduce costs. In the 10-20 K temperature range, MgB₂ superconductors carry current densities 100 times higher than standard copper conductors at room temperature at one tenth of the wire cost per unit carried current. In the framework of the European project INNWIND.EU, an MgB₂ superconducting generator pole will be designed, built and tested. Some of the design aspects of this work with emphasis on the winding process and associated coil insulation are discussed. An overall high current density in the coil is of crucial importance to obtain clear benefits compared to conventional solutions. The wire itself may be the most important parameter in that respect. However, the overall current density of the coil is also influenced by the thickness of the turn-to-turn electrical insulation. Here we discuss the impact of the insulation and suggest the use of a one-step winding process, employing wet-winding, where the applied epoxy also constitutes the insulation layer between turns. In this way the coil is densified by approximately 10% compared to the use of an additional, dedicated, electrical insulation like Kapton for wet-winding or glass-fibre for dry-winding followed by vacuum impregnation. We show the results of a trial winding of 500 m of MgB₂ superconducting wire into a double pancake coil using the wet-winding technique. The coil is tested for contacts between the turns to evaluate the suggested one-step wet-winding process.
Effects of an electromagnetic shield and armature teeth on the short-circuit performance of a direct drive superconducting generator for 10 MW wind turbines

To reduce the cost of energy of offshore wind energy conversion, large individual wind turbines of 10 MW or higher power levels are drawing more attention and expected to be desirable. Conventional wind generator systems would be rather large and costly if scaled up to 10 MW. Direct drive superconducting generators have been proposed to reduce the generator size, because the electrical machines with superconducting windings are capable of achieving a higher torque density. However, a superconducting machine is likely to produce an excessive torque during a short circuit because of its small reactance. An electromagnetic (EM) shield between the rotor and the stator as well as iron or non-magnetic composite (NMC) armature teeth affects the sub-transient reactance of a superconducting machine so that they play a role in the short-circuit performance of a superconducting wind generator. This paper presents a 10 MW superconducting generator design and studies the effects of material, thickness and position of an EM shield and the effects of NMC and iron armature teeth on the torque and the field current density during a three-phase short circuit at the generator terminal. One result shows that the short circuit torque is not able to be effectively reduced by varying the EM shield and the armature tooth material. The other result shows that the field current density is likely to exceed its critical value during a short circuit although the EM shield material and the armature tooth material take some effect.

Potential of MgB$_2$ superconductors in direct drive generators for wind turbines

Topologies of superconducting direct drive wind turbine generators are based on a combination of superconducting wires wound into field coils, copper armature windings, steel laminates to shape the magnetic flux density and finally structural materials as support. But what is the most optimal topology for superconducting wind turbine generators? This question is investigated by assuming some unit cost of the different materials and then minimizing the cost of the active materials of a 10 MW and 9.65 rpm direct drive wind turbine generator intended to be mounted in front of the INNWIND.EU King-Pin concept nacelle. A series of topologies are investigate by adding more iron components to the generator, such as rotor back iron, field winding pole, magnetic teeth and armature back iron. This method is used to investigate 6 topologies and to determine the optimal cost of the different topologies by using the current cost of 4 €/m for the MgB2 wire from Columbus Superconductors and also a possible future cost of 1 €/m if a superconducting offshore wind power capacity of 10 GW has been introduced by 2030 as suggested in a roadmap. The obtained topologies are compared to what is expected from a permanent magnet direct drive generators and the further development directions are discussed. Finally an experimental INNWIND.EU demonstration showing that the current commercial MgB2 wires can be wound into
Two level undercut-profile substrate for filamentary YBa$_2$Cu$_3$O$_7$ coated conductors: Fast Track Communication

A novel substrate design is presented for scalable industrial production of filamentary coated conductors (CCs). The new substrate, called 'two level undercut-profile substrate (2LUPS)', has two levels of plateaus connected by walls with an undercut profile. The undercuts are made to produce a shading effect during subsequent deposition of layers, thereby creating gaps in the superconducting layer deposited on the curved walls between the two levels. It is demonstrated that such 2LUPS-based CCs can be produced in a large-scale production system using standard deposition processes, with
Inspection of the conductor cross-section reveals that the deposited superconducting layer is physically separated at the 2LUPs undercuts. Filament decoupling is also seen in maps of the remanent magnetic field and confirmed by transport measurements.
Design of an MgB$_2$ race track coil for a wind generator pole demonstration

An MgB$_2$ race track coil intended for demonstrating a down scaled pole of a 10 MW direct drive wind turbine generator has been designed. The coil consists of 10 double pancake coils stacked into a race track coil with a cross section of 84 mm × 80 mm. The length of the straight section is 0.5 m and the diameter of the end sections is 0.3 m. Expanded to a straight section of 3.1 m it will produce about 1.5 T magnetic flux density in the air gap of the 10 MW 32 pole generator and about 3.0 T at the edge of the superconducting coil with an operation current density of the coil of 70 A/mm$^2$.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Center for Electric Power and Energy, SINTEF, Delft University of Technology
Authors: Abrahamsen, A. B. (Intern), Magnusson, N. (Ekstern), Jensen, B. B. (Intern), Liu, D. (Ekstern), Polinder, H. (Ekstern)
Number of pages: 4
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 507
Issue number: 3
Article number: 032001
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
Design study of a 10 MW MgB2 superconductor direct drive wind turbine generator

A superconducting direct drive generator based on field windings of MgB2 superconducting tape is proposed as a solution by mounting the generator in front of the blades using a king-pin nacelle design for offshore turbines with power ratings larger than 10 MW as investigated in the INNWIND.EU project.

Design of an MgB2 race track.pdf
DOIs:
10.1088/1742-6596/507/3/032001

Bibliographical note
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Source: FindIt
Source-ID: 267313792
Publication: Research - peer-review › Conference article – Annual report year: 2014

Design study of a 10 MW MgB2 superconductor direct drive wind turbine generator

A superconducting direct drive generator based on field windings of MgB2 superconducting tape is proposed as a solution by mounting the generator in front of the blades using a king-pin nacelle design for offshore turbines with power ratings larger than 10 MW as investigated in the INNWIND.EU project.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, SINTEF, Delft University of Technology, DNV-GL Oil & Gas
Authors: Abrahamsen, A. B. (Intern), Magnusson, N. (Ekstern), Liu, D. (Ekstern), Stehouwer, E. (Ekstern), Hendriks, B. (Ekstern), Polinder, H. (Ekstern)
Number of pages: 7
Publication date: 2014

Host publication information
Title of host publication: Proceedings of EWEA 2014
Design study of a 10 MW MgB₂ superconductor direct drive wind turbine generator

A design study of a 10 MW direct drive wind turbine generator based on MgB₂ superconducting wires is presented and the cost of the active materials of the generator is estimated to be between 226 €/kW and 84 €/kw, which is lower than the threshold values of 300 €/kW of the INNWIND.EU project. A nacelle structure with a front-mounted generator is presented for further investigation of the integration of such a superconducting generator into offshore turbines with power ratings considerably larger than 10 MW.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, SINTEF, Delft University of Technology, DNV-GL Oil & Gas
Authors: Abrahamsen, A. B. (Intern), Magnusson, N. (Ekstern), Liu, D. (Ekstern), Stehouwer, E. (Ekstern), Hendriks, B. (Ekstern), Polinder, H. (Ekstern)
Number of pages: 1
Publication date: 2014
Main Research Area: Technical/natural sciences
Superconducting generator, Direct drive generator, Offshore wind turbine, Nacelle integration
Electronic versions:
Design_study_of_a_10_MW_poster.pdf
Publication: Research - peer-review › Poster – Annual report year: 2014

Emerging wind energy technologies

This chapter will discuss emerging technologies that are expected to continue the development of the wind sector to embrace new markets and to become even more competitive.

General information
State: Published
Authors: Rasmussen, F. (Intern), Grivel, J. (Intern), Faber, M. H. (Intern), Mijatovic, N. (Intern), Abrahamsen, A. B. (Intern)
Pages: 52-62
Publication date: 2014
Host publication information
Title of host publication: DTU International Energy Report 2014 : Wind energy — drivers and barriers for higher shares of wind in the global power generation mix
Publisher: Technical University of Denmark (DTU)
Editors: Hvidtfeldt Larsen, H., Sønderberg Petersen, L.
ISBN (Print): 978-87-550-3969-8
Main Research Area: Technical/natural sciences
Electronic versions:
DTU_INTL_ENERGY_REP_2014_WIND_52_62.pdf
Publication: Research - peer-review › Book chapter – Annual report year: 2014

Hysteresis losses in MgB₂ superconductors exposed to combinations of low AC and high DC magnetic fields and transport currents

MgB₂ superconductors are considered for generator field coils for direct drive wind turbine generators. In such coils, the losses generated by AC magnetic fields may generate excessive local heating and add to the thermal load, which must be removed by the cooling system. These losses must be evaluated in the design of the generator to ensure a sufficient overall efficiency. A major loss component is the hysteresis losses in the superconductor itself. In the high DC – low AC current and magnetic field region experimental results still lack for MgB₂ conductors. In this article we reason towards a simplified theoretical treatment of the hysteresis losses based on available models in the literature with the aim of setting the basis for estimation of the allowable magnetic fields and current ripples in superconducting generator coils intended for large wind turbine direct drive generators. The resulting equations use the DC in-field critical current, the geometry of the
superconductor and the magnitude of the AC magnetic field component as parameters. This simplified approach can be valuable in the design of MgB2 DC coils in the 1–4T range with low AC magnetic field and current ripples.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, SINTEF, Delft University of Technology
Authors: Magnusson, N. (Ekstern), Abrahamsen, A. B. (Intern), Liu, D. (Ekstern), Runde, M. (Ekstern), Polinder, H. (Ekstern)
Pages: 133-137
Publication date: 2014
Main Research Area: Technical/natural sciences

Publication information
Journal: Physica C: Superconductivity and its Applications
Volume: 506
ISSN (Print): 0921-4534
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.858 SJR 0.492 CiteScore 1.28
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.14 SJR 0.467 SNIP 0.822
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.427 SNIP 0.759 CiteScore 0.99
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.501 SNIP 0.781 CiteScore 0.85
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.46 SNIP 0.649 CiteScore 0.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.575 SNIP 0.604 CiteScore 0.79
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.694 SNIP 0.606 CiteScore 0.94
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.67 SNIP 0.632
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.422 SNIP 0.561
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.676 SNIP 0.577
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.555 SNIP 0.725
Scopus rating (2006): SJR 0.682 SNIP 0.629
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.822 SNIP 0.664
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.816 SNIP 0.655
Superconducting wind turbine generators

A HTS machine could be a way to address some of the technical barriers offshore wind energy is about to face. Due to the superior power density of HTS machines, this technology could become a milestone on which many, including the wind industry, will rely on in the future. The work presented in this thesis is a part of a larger endeavor, the Superwind project that focused on identifying the potentials that HTS machines could offer to the wind industry and addressing some of the challenges in the process. In order to identify these challenges, I have designed and constructed an HTS machine experimental setup which is made to serve as precursor, leading towards an optimized HTS machine concept proposed for wind turbines. In part, the work presented in this thesis will focus on the description of the experimental setup and reasoning behind the choices made during the design. The setup comprises an HTS synchronous machine where a revolving armature winding spins around an open bath liquid nitrogen cryostat, which contains the HTS coils cooled down to 77 K. A significant part of the thesis is allocated to the description of the setup, particularly the torque transfer element and the compact cryostat design, where a concept with 20 W of heat transfer is achieved. Following the setup description, the focus turns to the electromagnetic design of the HTS machine. Particularly, an approach to increase the performance of HTS coils and the influence of the armature reaction to the HTS field winding will be discussed. Two design strategies are proposed, novel in a machine design, in order to reduce the amount of HTS required in a machine whereby the merits of both have been experimentally verified. The first employs a multiple HTS types in the machine design, since each type of the HTS tape has a specific magnetic characteristic with respect to the critical current. I have showed that the potential for the reduction of HTS conductor can be significant, if the coils are placed strategically, whereby the coils wound with BSCCO performed 40% better depending on the placement in the field winding. The 2G coils were less sensitive to the placement which made them particularly useful for high magnetic field regions in the field winding. The second design approach proposed and tested was to use multiple current supplies which allowed each coil to operate close to its critical current. I have demonstrated that by introducing one additional power supply, an order of 12% higher MMF was generated (or equivalent HTS savings achieved). Increasing in the number of additional power supplies did not show the same potential for HTS reduction. The implications of an armature reaction impact on the HTS field Winding performance were examined and verified throughout a series of Locked Armature experiments. The interaction have been dened in the terms of two (direct and quadrature) axis machine theory (Park transformation), where significant reduction of 20% was observed for the rated armature reaction in the q axis. Building on this observation, a control strategy for the excitation current to improve a partial load ecieny of a HTS machine is proposed. Thus, this work has shown that a significant savings of a costly HTS tape could be realized indicating that the HTS machine design can still be optimized towards more competitive alternative to conventional machines. Additionally, by constructing the HTS machine setup we went through most of the issues related to the HTS machine design which we managed to address in rather simple manner using everyday materials and therefore proving that HTS machines are close to commercialization.
Calculation of alternating current losses in stacks and coils made of second generation high temperature superconducting tapes for large scale applications

A homogenization method to model a stack of second generation High Temperature Superconducting tapes under AC applied transport current or magnetic field has been obtained. The idea is to find an anisotropic bulk equivalent for the stack such that the geometrical layout of the internal alternating structures of insulating, metallic, superconducting, and substrate layers is "washed" out while keeping the overall electromagnetic behavior of the original stack. We disregard assumptions upon the shape of the critical region and use a power law E-J relationship allowing for overcritical current densities to be considered. The method presented here allows for a computational speedup factor of up to 2 orders of magnitude when compared to full 2-D simulations taking into account the actual dimensions of the stacks without compromising accuracy.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Department of Applied Mathematics and Computer Science, Dynamical Systems, Karlsruhe Institute of Technology KIT
Authors: Zermeno, V. M. R. (Ekstern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Jensen, B. B. (Intern), Sørensen, M. P. (Intern)
Number of pages: 9
Pages: 173901
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Physics
Volume: 114
Issue number: 17
ISSN (Print): 0021-8979
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.953 SJR 0.739 CiteScore 2.03
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.72 SJR 0.906 SNIP 0.977
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.821 SNIP 0.996 CiteScore 1.57
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.039 SNIP 1.197 CiteScore 2.04
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.155 SNIP 1.286 CiteScore 2.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.312 SNIP 1.291 CiteScore 2.13
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Development of superconducting wind turbine generators

In this paper, the commercial activities in the field of superconducting machines, particularly superconducting wind turbine generators, are reviewed and presented. Superconducting generators have the potential to provide a compact and lightweight drive train at high torques and slow rotational speeds, because high magnetic fields can be produced by coils with very little loss. Three different superconducting wind turbine generator topologies have been proposed by three different companies. One is based on low temperature superconductors; one is based on high temperature superconductors; and one is a fully superconducting generator based on MgB2. It is concluded that there is large commercial interest in superconducting machines, with an increasing patenting activity. Such generators are, however, not without their challenges. The superconductors have to be cooled down to somewhere between 4 K and 50 K, depending on what type of superconductor is employed, which poses a significant challenge both from a construction and operation point of view. The high temperature superconductors can facilitate a higher operation temperature and simplified cooling, but the current price and production volumes prohibit a large scale impact on the wind sector. The low temperature superconductors are readily available, but will need more sophisticated cooling. Eventually the Cost of Energy from superconducting wind turbines, with particular emphasis on reliability, will determine if they become feasible or not and for such investigations large-scale demonstrations will be needed. © 2013 AIP Publishing LLC.
Rare materials - can we compete for them on the global market?

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems
Authors: Abrahamsen, A. B. (Intern)
Pages: 47-48
Publication date: 2013

Host publication information
Title of host publication: Offshore wind energy in the South Baltic Region – challenges and opportunities
Publisher: Drukarnia WL
Editors: Tonderski, A., Jędrzejewska, A.
ISBN (Print): 978-83-933461-8-9
Main Research Area: Technical/natural sciences
Electronic versions:
Reducing Conductor Usage in Superconducting Machines by Multiple Power Supplies
This paper presents and applies a method of reducing the needed amount of superconductor in a superconducting machine by supplying the superconductor from multiple power supplies. The method is presented and validated experimentally in a constructed prototype. Thereafter, a superconducting tape is tested experimentally for allowable current density in a flux density spanning from 0 to 16 T and a temperature range from 5 K to 85 K. Using the experimental data from the superconductor, the proposed method is applied to minimize the usage of superconductor in a 10-MW superconducting direct drive wind turbine generator.

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Department of Wind Energy, Wind Energy Systems
Authors: Jensen, B. B. (Intern), Mijatovic, N. (Intern), Abrahamsen, A. B. (Intern)
Number of pages: 8
Pages: 5202708
Publication date: 2013
Main Research Area: Technical/natural sciences

Publication information
Journal: I E E E Transactions on Applied Superconductivity
Volume: 23
Issue number: 5
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.555 SNIP 1.274 CiteScore 1.11
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.368 SNIP 1.062 CiteScore 1.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.473 SNIP 1.065
Superconducting direct drive generators for large offshore wind turbines

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Delft University of Technology
Authors: Abrahamsen, A. B. (Intern), Jensen, B. B. (Intern), Polinder, H. (Ekstern)
Number of pages: 12
Publication date: 2013

Publication information
Original language: English
Publisher: European Wind Energy Association (EWEA)
Main Research Area: Technical/natural sciences
Electronic versions: Superconducting_direct_drive_presentation.pdf
Links:
http://www.ewea.org/annual2013/
Publication: Research › Sound/Visual production (digital) – Annual report year: 2013

Superleder tapes karakteriseret fra nanometer pinning til meter store spoler

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems
Authors: Abrahamsen, A. B. (Intern)
Publication date: 2013

Publication information
Original language: Danish
Publisher: Dansk Metallurgisk Selskab
Trends in Wind Turbine Generator Systems

This paper reviews the trends in wind turbine generator systems. After discussing some important requirements and basic relations, it describes the currently used systems: the constant speed system with squirrel-cage induction generator, and the three variable speed systems with doubly fed induction generator (DFIG), with gearbox and fully rated converter, and direct drive (DD). Then, possible future generator systems are reviewed. Hydraulic transmissions are significantly lighter than gearboxes and enable continuously variable transmission, but their efficiency is lower. A brushless DFIG is a medium speed generator without brushes and with improved low-voltage ride-through characteristics compared with the DFIG. Magnetic pseudo DDs are smaller and lighter than DD generators, but need a sufficiently low and stable magnet price to be successful. In addition, superconducting generators can be smaller and lighter than normal DD generators, but both cost and reliability need experimental demonstration. In power electronics, there is a trend toward reliable modular multilevel topologies.

Advantages and Challenges of Superconducting Wind Turbine Generators

General information
An HTS machine laboratory prototype

This paper describes Superwind HTS machine laboratory setup which is a small scale HTS machine designed and built as a part of the efforts to identify and tackle some of the challenges the HTS machine design may face. One of the challenges of HTS machines is a Torque Transfer Element (TTE) which is in this design integral part of the cryostat. The discussion of the requirements for the TTE supported with a simple case study comparing a shaft and a cylinder as candidates for TTE are presented. The discussion resulted with a cylinder as a TTE design rated for a 250Nm and with more then 10 times lower heat conduction compared to a shaft. The HTS machine was successfully cooled to 77K and tests have been performed. The IV curves of the HTS field winding employing 6 HTS coils indicate that two of the coils had been damaged. The maximal value of the torque during experiments of 78Nm was recorded. Loaded with 33%, the TTE performed well and showed sufficient margin for future experiments.

General information

State: Published
Organisations: Department of Electrical Engineering, Electric Components, Department of Wind Energy, Wind Energy Systems, Department of Mathematics, Dynamical systems
Pages: 771-776
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information

Journal: Physics Procedia
Volume: 36
ISSN (Print): 1875-3892
Ratings:
Scopus rating (2017): SNIP 0.614 SJR 0.351 CiteScore 0.67
Scopus rating (2016): CiteScore 0.65 SJR 0.347 SNIP 0.574
Scopus rating (2015): SJR 0.262 SNIP 0.572 CiteScore 0.61
Scopus rating (2014): SJR 0.401 SNIP 0.696 CiteScore 0.78
Scopus rating (2013): SJR 0.29 SNIP 0.605 CiteScore 0.72
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.28 SNIP 0.623 CiteScore 0.5
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.227 SNIP 0.467 CiteScore 0.45
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.218 SNIP 0.318
Scopus rating (2009): SJR 0.202 SNIP 0.456
Original language: English
HTS machine, Torque Transfer Element, HTS coils
DOIs:
10.1016/j.phpro.2012.06.041

Bibliographical note
Calculation of AC losses in HTS stacks and coils for large scale applications

Nowadays, research is performed on designing motors, generators, and magnets that would take advantage of the high magnetic field achieved by HTS coils. Although these devices are designed so that their HTS elements do not experience AC fields, hysteretic losses are expected during transient operation. Calculating these losses is fundamental for performance evaluation and design. In many cases, this boils down to computing AC losses in stacks of tapes that are subjected to transport current and/or applied magnetic field. In this work, we present a homogenization method to model a stack of HTS tapes. The idea is to find an anisotropic bulk equivalent for the stack of tapes: "washing out" the geometric internal features of the stack while keeping its overall electromagnetic behavior. Our work extends the anisotropic bulk model originally presented by Clem et al. and later refined by Prigozhin and Sokolovsky. We disregard assumptions upon the shape of the critical region and use a power law E-J relationship allowing for overcritical current densities to be considered. This plays an important role when considering transient response of devices or non-harmonic oscillations. The method presented here allowed for a computational speedup factor of up to 2 orders of magnitude when compared to full 2-D simulations taking into account the actual structure of the stacks without compromising accuracy.

General information
State: Published
Organisations: Department of Mathematics, Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Department of Informatics and Mathematical Modeling, Dynamical systems
Authors: Rodríguez Zermeno, V. M. (Intern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Jensen, B. B. (Intern), Sørensen, M. P. (Intern)
Pages: 893-893
Publication date: 2012

Host publication information
Title of host publication: Conference program book - 2012 Applied Superconductivity Conference (ASC 2012)
Main Research Area: Technical/natural sciences
Conference: 2012 Applied Superconductivity Conference, Portland, OR, United States, 07/10/2012 - 07/10/2012
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2012

Calculation of AC losses in large HTS stacks and coils

In this work, we present a homogenization method to model a stack of HTS tapes under AC applied transport current or magnetic field. The idea is to find an anisotropic bulk equivalent for the stack of tapes, where the internal alternating structures of insulating, metallic, superconducting and substrate layers are reduced while keeping the overall electromagnetic behavior. Our work extends the anisotropic bulk model originally presented by Clem et al. and later refined by Prigozhin and Sokolovsky. We disregard assumptions upon the shape of the critical region and use a power law E-J relationship allowing for overcritical current densities to be considered. The method presented here allowed for a computational speedup factor of up to 2 orders of magnitude when compared to full 2-D simulations taking into account the actual structure of the stacks without compromising accuracy.

General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Department of Informatics and Mathematical Modeling, Dynamical systems, Karlsruhe Institute of Technology KIT
Authors: Zermeno, V. (Ekstern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Jensen, B. B. (Intern), Sørensen, M. P. (Intern)
Number of pages: 2
Publication date: 2012

Host publication information
Title of host publication: Proceedings of International Conference on Coated Conductors for Applications (CCA2012)
Main Research Area: Technical/natural sciences
Conference: International Conference on Coated Conductors for Applications (CCA 2012), Heidelberg, Germany, 13/11/2012 - 13/11/2012
Links: Finite-element modeling, AC losses, coils, homogenization
Electronic versions:
Comparison of MgB$_2$ and Coated Conductor Based 5 MW Superconducting Wind Turbine Generator

Direct drive superconducting generators might become attractive in large offshore wind turbines, because the drive train must provide a torque scaling with the radius of the rotor blades as $R^3$ due to limitation of the tip speed of the blades. We have previously found that a coated conductor based generator can technically compete with a gear box drive train equivalent to the 5 MW NREL reference turbine [1]. However the price of the coated conductor results in a generator price exceeding the expected price of the entire turbine. MgB$_2$ conductors can be seen as a low cost alternative to the coated conductors, but the operation temperature in range of $T = 15-20$ K and the engineering current density $J_e$ is smaller. We have found that a 16 pole synchronous generator with active diameter $D = 4.2$ m and length $L = 1.5$ m based on a MgB$_2$ wire with $J_e = 70$ A/mm$^2$ in approximately 4 Tesla field would result in a wire usage in the order of 330 km. This has the potential to decrease the price of the superconductor wires in the generator by a factor of 10 compared to the coated conductors, but the cryogenics will be a challenge and is discussed. Finally we will use turbine load simulations to discuss the torque events that such a 5 MW generator would experience if installed in the NREL turbine.

Critical current density measurement of thin films by AC susceptibility based on the penetration parameter $h$

We have numerically proved that the dependence of AC susceptibility $\chi$ of a $E(J)$ power law superconducting thin disc on many parameters can be reduced to one penetration parameter $h$, with $E$ the electric field and $J$ the current density. Based on this result, we propose a way of measuring the critical current density $J_c$ of superconducting thin films by AC susceptibility. Compared with the normally used method based on the peak of the imaginary part, our method uses a much larger range of the AC susceptibility curve, thus allowing determination of the temperature ($T$) dependence of $J_c$ from a normally applied $\chi(T)$ measurement. A fitting equation $J_c=1.9Ha|\chi'|0.69/d, \sim -0.4$
Design study of coated conductor direct drive wind turbine generator for small scale demonstration
We have investigated the properties of a superconducting direct drive generator suitable for demonstration in a small scale 11 kW wind turbine. The engineering current density of the superconducting field windings is based on properties of coated conductors wound into coils holding of the order 68 meters of tape. The active mass of the generators has been investigated as function of the number of poles and a 4 pole generator is suggested as a feasible starting point of an in-field demonstration of the system reliability. An active mass of $m = 421$ kg and a usage of 3.45 km of tape will be needed to realize such a generator with a peak flux density in the airgap of $B_0 = 1.5$ T.

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General information
State: Published
Organisations: Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Electric Components
Authors: Abrahamsen, A. B. (Intern), Jensen, B. B. (Intern)
Pages: 753-758
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Physics Procedia
Volume: 36
ISSN (Print): 1875-3892

Ratings:
Scopus rating (2017): SNIP 0.614 SJR 0.351 CiteScore 0.67
Scopus rating (2016): CiteScore 0.65 SJR 0.347 SNIP 0.574
Scopus rating (2015): SJR 0.262 SNIP 0.572 CiteScore 0.61
Scopus rating (2014): SJR 0.401 SNIP 0.696 CiteScore 0.78
Scopus rating (2013): SJR 0.29 SNIP 0.605 CiteScore 0.72
ISI indexed (2013): ISI indexed no
Scopus rating (2012): SJR 0.28 SNIP 0.623 CiteScore 0.5
ISI indexed (2012): ISI indexed no
Web of Science (2012): Indexed yes
Scopus rating (2011): SJR 0.27 SNIP 0.467 CiteScore 0.45
ISI indexed (2011): ISI indexed no
Scopus rating (2010): SJR 0.218 SNIP 0.318
Scopus rating (2009): SJR 0.202 SNIP 0.456
Original language: English
DOIs: 10.1016/j.phpro.2012.06.038

Bibliographical note
EUCAS Conference 2011
Publication: Research - peer-review › Journal article – Annual report year: 2012

Development of Superconducting Wind Turbine Generators
In this paper the commercial activities in the field of superconducting machines, particularly superconducting wind turbine generators, are reviewed and presented. Superconducting generators have the potential to provide a compact and light weight drive train at high torques and slow rotational speeds, because high magnetic fields can be produced by coils with very little loss.

Three different superconducting wind turbine generator topologies have been proposed by three different companies. One is based on low temperature superconductors (LTS); one is based on high temperature superconductors (HTS); and one is a fully superconducting generator based on MgB2. It is concluded that there is large commercial interest in superconducting machines, with an increasing patenting activity.

Such generators are however not without their challenges. The superconductors have to be cooled down to somewhere between 4K and 50K, depending on what type of superconductor is employed, which poses a significant challenge both from a construction and operation point of view. The high temperature superconductors can facilitate a higher operation temperature and simplified cooling, but the current price and production volumes prohibit a large scale impact on the wind sector. The low temperature superconductors are readily available, but will need more sophisticated cooling.

Eventually the CoE from superconducting wind turbines, with particular emphasis on reliability, will determine if they become feasible or not and for such investigations large-scale demonstrations will be needed.
In-Situ Synchrotron X-ray Study of the Phase and Texture Evolution of Ceria and Superconductor Films Deposited by Chemical Solution Method

In situ synchrotron x-ray diffraction is used to study the phase and texture formation of ceria based films and superconductor films deposited by the chemical solution method on technical substrates. Combined analysis using in situ synchrotron x-ray diffraction, thermogravimetry/differential thermal analysis and Fourier transform infra-red (FTIR) spectroscopy allows to study the details on the decomposition and crystallization processes of ceria based in form of bulk and film. The success of this work demonstrates the possibility of studying chemical reaction pathway and texture evolution of oxides starting from solution precursors using non destructive method.
Large superconducting wind turbine generators

To realize large (>10 MW) direct-driven off-shore wind turbines, a number of steps are needed to reduce weight and cost compared to on-shore technologies. One of the major challenges is to provide drive trains which can comply with the large torque as the turbine rotor diameter is scaled up and the rotation speed is lowered in order to limit the tip speed of the blades. The ability of superconducting materials to carry high current densities with very small losses might facilitate a new class of generators operating with an air gap flux density considerably higher than conventional generators and thereby having a smaller size and weight [1, 2]. A 5 MW superconducting wind turbine generator forms the basics for the feasibility considerations, particularly for the YBCO and MgB2 superconductors entering the commercial market. Initial results indicate that a 5 MW generator with an active weight of 34 tons, diameter of 4.2 m and length of 1.2 m can be realized using superconductors carrying 300 A/mm² in a magnetic field of 4 T and an air gap flux density of the order 2.5 T. The results are compared to the performance of available superconductors, as well as the near future forecasted performance.
Measurement of AC losses in a racetrack superconducting coil made from YBCO coated conductor

We present the results of transport measurements of AC losses in a racetrack shaped superconducting coil made from coated conductor tape. The outer dimensions of the coil are approximately 24 cm × 12 cm and it has 57 turns. The coil is impregnated with epoxy resin and fiberglass tape is used to insulate the individual turns and to improve the mechanical properties of the epoxy when exposed to thermal cycling. The coil is manufactured as a part of the field winding of a small synchronous generator; therefore stainless steel frames are installed on the inner and outer side of the winding to reinforce it. The AC loss is measured versus the transport current Ia with the coil immersed in liquid nitrogen. Measurements at frequencies 21 Hz, 36 Hz and 72 Hz are compared. The AC losses follow I2 a dependence at low current amplitudes and I3 a at high amplitudes. After cutting the inner steel frame the low amplitude losses are decreased, their frequency dependence is reduced but their dependence on the current remains unchanged.

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Model and Simulation of a HTS Generator under transient response

Use of HTS field windings in electrical rotating machines can increase the torque density by a factor of 2-3 compared to conventional designs. This is highly attractive for large scale applications, such as ship propulsion and wind turbines. However, design considerations have to take into account hysteresis losses in the HTS materials during transients. Modeling and simulation of these transients is a very challenging task. It requires considering a system that spans spatially 6 orders of magnitude: from the μm thick superconducting layers in the windings, to a few meters in diameter and length of the MW class machines. In this work, we present a bottom-up model of a 10MW HTS slotless generator for a direct drive wind turbine application. The model is used to simulate the transient response of the generator where focus is placed on the losses associated with ramp-up of HTS coils with different rise times and transient responses. Hence, transient hysteresis losses in the superconducting coils were computed. This allowed addressing several important design and performance issues such as defining the safety margin of the load line to the critical current of the superconducting coils, electric load change rate, cryostat design and identification of quench-prone regions.

General information
State: Published
Organisations: Department of Mathematics, Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Center for Electric Power and Energy, Department of Informatics and Mathematical Modeling, Dynamical systems
Authors: Rodriguez Zermeno, V. M. (Intern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Jensen, B. B. (Intern), Sørensen, M. P. (Intern)
Pages: 746-746
Publication date: 2012

Host publication information
Title of host publication: Conference program book - 2012 Applied Superconductivity Conference (ASC 2012)
Main Research Area: Technical/natural sciences
Conference: 2012 Applied Superconductivity Conference, Portland, OR, United States, 07/10/2012 - 07/10/2012
Links:

Simulation of an HTS Synchronous Superconducting Generator

In this work we present a simulation of a synchronous generator with superconducting rotor windings. As many other, electrical rotating machines, superconducting generators are exposed to ripple fields that could be produced from a wide variety of sources: short circuit, load change, mechanical torque fluctuations, etc. Unlike regular conductors, superconductors, experience high losses when exposed to AC fields. Thus, calculation of such losses is relevant for machine design to avoid quenches and increase performance. Superconducting coated conductors are well known to exhibit nonlinear resistivity, thus making the computation of heating losses a cumbersome task. Furthermore, the high aspect ratio of the superconducting materials involved adds a penalty in the time required to perform simulations. The chosen strategy for simulation is as follows: A mechanical torque signal together with an electric load is used to drive the finite element model of a synchronous generator where the current distribution in the rotor windings is assumed uniform. Then, a second finite element model for the superconducting material is linked to calculate the actual current distribution in the windings of the rotor. Finally, heating losses are computed as a response to the electric load. The model is used to evaluate the transient response of the generator.

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General information
State: Published
Organisations: Department of Mathematics, Dynamical systems, Department of Wind Energy, Wind Energy Systems, Department of Electrical Engineering, Electric Components
Authors: Rodriguez Zermeno, V. M. (Intern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Sørensen, M. P. (Intern), Jensen, B. B. (Intern), Pedersen, N. F. (Intern)
Pages: 786-790
Publication date: 2012
Main Research Area: Technical/natural sciences

Publication information
Journal: Physics Procedia
Volume: 36
ISSN (Print): 1875-3892
Superconducting Direct Drive Wind Turbine Generators: Advantages and Challenges

General information
State: Published
Organisations: Electric Components, Department of Electrical Engineering
Authors: Abrahamsen, A. B. (Intern), Jensen, B. B. (Intern)
Number of pages: 366
Pages: 53-80
Publication date: 2012

Host publication information
Title of host publication: Wind Energy Conversion Systems. Technology and trends
Publisher: Springer Publishing Company
Editor: Muyeen, S.
Series: Green Energy and Technology
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 318434
Publication: Research - peer-review › Book chapter – Annual report year: 2012

Superconducting Wind Turbine Generators
A HTS machine could be a way to address some of the technical barriers offshore wind energy is about to face. Due to the superior power density of HTS machines, this technology could become a milestone on which many, including the wind industry, will rely in the future. The work presented in this thesis is a part of a larger endeavor, the Superwind project that focused on identifying the potentials that HTS machines could offer to the wind industry and addressing some of the challenges in the process. In order to identify these challenges, I have design and constructed a HTS machine experimental setup which is made to serve as precursor, leading towards an optimized HTS machine concept proposed for wind turbines.

In part, the work presented in this thesis will focus on the description of the experimental setup and reasoning behind the choices made during the design. The setup comprises from a HTS synchronous machine where a revolving armature winding spins around an open bath liquid nitrogen cryostat, which contains the HTS coils cooled down to 77 K. A significant part of the thesis is allocated to the description of the setup, particularly the torque transfer element and the compact cryostat design, where a concept with ~20 W of heat transfer is achieved.

Following the setup description, the focus turns to the electromagnetic design consideration of the HTS machine. Particularly, an approach to increase the performance of HTS coils and the influence of the armature reaction to the HTS field winding will be discussed.

Two design strategies are proposed, novel in a machine design, in order to reduce the amount of HTS required in a machine whereby the merits of both have been experimentally verified. The first employs a multiple HTS types in the machine design, since each type of the HTS tape has a specific magnetic characteristic with respect to the critical current. I have showed that the potential for the reduction of HTS conductor can be significant, if the coils are placed strategically,
whereby the coils wound with BSCCO performed 40% better depending on the placement in the field winding. The 2G coils were less sensitive to the placement which made them particularly useful for high magnetic field regions in the field winding. The second design approach proposed and tested was to use multiple current supplies which allowed each coil to operate close to its critical current. I have demonstrated that by introducing one additional power supply, an order of 12% higher MMF was generated (or equivalent HTS savings achieved). Increasing in the number of additional power supplies did not show the same potential for HTS reduction.

The implications of an armature reaction impact on the HTS field winding performance were examined and verified throughout a series of Locked Armature experiments. The interaction have been defined in the terms of two (direct and quadrature) axis machine theory (Park transformation), where significant reduction of ~ 20% was observed for the rated armature reaction in the q axis. Building on this observation, a control strategy for the excitation current to improve a partial load efficiency of a HTS machine is proposed.

Thus, this work has shown that a significant savings of a the costly HTS tape could be realized indicating that the HTS machine design can still be optimized towards more competitive alternative to conventional machines. Additionally, by constructing the HTS machine setup we went through most of the issues related to the HTS machine design which we managed to address in rather simple manner using everyday materials and therefore proving that HTS machines are close to commercialization.

**General information**

State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Department of Wind Energy, Wind Energy Systems
Authors: Mijatovic, N. (Intern), Jensen, B. B. (Intern), Abrahamsen, A. B. (Intern), Træholt, C. (Intern)
Number of pages: 285
Publication date: 2012

**Publication information**

Place of publication: Kgs. Lyngby
Publisher: Technical University of Denmark (DTU)
Original language: English
Main Research Area: Technical/natural sciences

**AC Losses in Bi2Sr2Ca2Cu3O10+x Tapes and a 3.15-m-Long Single-Phase Cable**

The alternating-current losses in superconducting multifilament BiSCCO-2223 tapes and a 3.15-m single-phase test cable were measured at 77 K using an electrical transport method. The cable had an inner diameter of 42 mm; it was composed of a single layer of 31 multifilament tapes and had a critical current of $I_{c} = 4.1\ \hbox{kA}$. The measured losses of the tapes were found to be in good agreement with the Norris ellipse (NE) model. The losses of the cable were, for high currents, found to be bounded by the monoblock and independent NE models.

**General information**

State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Electric Components, Department of Electrical Engineering, University of Southern Denmark, Ultera—A Southwire/NKT Cables Joint Venture (DK), University of Copenhagen
Pages: 3599-3603
Publication date: 2011
Main Research Area: Technical/natural sciences
In this paper a course on applied superconductivity is described. The course structure is outlined and the learning objectives and the learning activities are described. The teaching was multidisciplinary given by four departments each contributing with their expertise. Being applied superconductivity the focus was on an application, which could benefit from using superconductors. The application used in this course was superconducting generators for direct drive wind turbines. As part of the course the students built a small-scale superconducting machine and set up finite element models of that machine as well as large-scale wind turbine generators with superconductors and also permanent magnet generators. The course was assessed by a student conference contribution and reports from the students. The quality of the course was evaluated by interviewing the students after the course had finished. The students were very pleased with the course and
gave suggestions of how the course could be improved further.

**Active materials for future wind turbine generators: From Copper to R2Fe14B and RBa2Cu3O6+x?**

**Coil Optimization for High Temperature Superconductor Machines**

This paper presents topology optimization of HTS racetrack coils for large HTS synchronous machines. The topology optimization is used to acquire optimal coil designs for the excitation system of 3 T HTS machines. Several tapes are evaluated and the optimization results are discussed. The optimization algorithm is formulated to minimize the cost for the coils wound with one type of HTS as well as multiple HTS types. It could also be used to minimize other parameters, e.g. space required for the coils. The results are inherently highly dependent on the HTS properties, which at 20 K seem to be in favor of the 1 G tape. The maximal HTS savings achieved allowing multiple current supplies in the excitation system are investigated and estimated to be in the range of 50% for highly nonlinear J-B dependence HTS tapes.
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.555 SNIP 1.274 CiteScore 1.11
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.368 SNIP 1.062 CiteScore 1.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.473 SNIP 1.065
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.447 SNIP 1.021
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.884 SNIP 0.981
Scopus rating (2007): SJR 0.629 SNIP 1.093
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.734 SNIP 1.05
Scopus rating (2005): SJR 0.652 SNIP 0.992
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.882 SNIP 0.904
Scopus rating (2003): SJR 0.51 SNIP 1.054
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.226 SNIP 1.024
Scopus rating (2001): SJR 0.552 SNIP 1.368
Web of Science (2001): Indexed yes
Scopus rating (2000): SJR 0.498 SNIP 0.998
Web of Science (2000): Indexed yes
Scopus rating (1999): SJR 1.054 SNIP 2.065

Original language: English
Topology optimization, Materials for fusion reactors, HTS machines, HTS coil optimization
Electronic versions: 05677620[1].pdf
DOIs: 10.1109/TASC.2010.2094171
Feasibility study of 5MW superconducting wind turbine generator

The feasibility of installing a direct drive superconducting generator in the 5MW reference offshore wind turbine of the National Renewable Energy Laboratory (NREL) has been examined. The engineering current densities $J_e$ obtained in a series of race track coils have been combined with magnetization measurements to estimate the properties of suitable field coils for a synchronous generator, which is more light weight than the conventional used combination of a gear box and a fast rotating generator. An analytical model and finite element simulations have been used to estimate the active mass of generators with varying number of poles. A 24 pole machine with an outer diameter of 4.2m and active length and mass of 1.2m and 34 tons is suggested possible, if a $J_e=300A/mm^2$ can be obtained in B=4T pointing to an operation temperature around 40K.
High Temperature Superconducting (HTS) technology for wind generators

General information
State: Published
Organisations: Department of Electrical Engineering, Electric Components, Risø National Laboratory for Sustainable Energy, Materials Research Division, Nano-Microstructures in Materials
Authors: Jensen, B. B. (Intern), Abrahamsen, A. B. (Intern)
Publication date: 2011

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
High_Temperature_Superconducting-HTS_Technology_for_Generators.pdf
Links:
http://www.wind-drivetrain.com/presentations
Source: orbit
Source-ID: 285838
Publication: Research › peer-review – Journal article – Annual report year: 2011

High Temperature Superconductor Machine Prototype
A versatile testing platform for a High Temperature Superconductor (HTS) machine has been constructed. The stationary HTS field winding can carry up to 10 coils and it is operated at a temperature of 77K. The rotating armature is at room temperature. Test results and performance for the HTS field winding comprising four coils wound with two types of HTS tapes are shown and discussed. The field winding produces up to 0.62T in the 10mm air gap which constitutes 78% of the
armature design value. Recommendations for the field winding operation are proposed and verified, which resulted in an increase of available magneto-motive force of the field winding up to 25%.

**General information**
State: Published
Organisations: Electric Components, Department of Electrical Engineering, Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Dynamical systems, Department of Mathematics, Electric Energy Systems
Publication date: 2011

**Host publication information**
Title of host publication: International Conference on Electrical Machines and Systems
Publisher: IEEE
ISBN (Print): 9781457710445
Main Research Area: Technical/natural sciences
Conference: International Conference on Electrical Machines and Systems 2011 : ICEMS 2011, Beijing, China, 01/01/2011
Windings, Torque, Steel, High temperature superconductors, Heat transfer, Coils
DOIs: 10.1109/ICEMS.2011.6073372
Source: orbit
Source-ID: 281866
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

**HTS machine laboratory prototype**
High Temperature Superconducting (HTS) electrical machines have the potential to offer outstanding technical performance with regards to efficiency and power density. However, the industry needs to address a large number of challenges in the attempt to harvest the full potential of HTS machines. Among others a few stand out, e.g. reliability and efficiency of thermal insulation and cooling systems; optimized torque transfer elements and current leads; commercial availability and competitiveness of HTS material etc. Also, HTS conductors lack standardization due to their rapid development where many of HTS properties are not known and need to be tested with a specific purpose in mind not just for different types of HTS conductors but also for the same type of HTS conductors made by different manufactures. To address some of these challenges, we have constructed a laboratory prototype HTS machine. The machine comprises six stationary HTS field windings wound from both YBCO and BISCOO tape operated at liquid nitrogen temperature and enclosed in a cryostat, and a three phase armature winding spinning at up to 300 rpm. This design has full functionality of HTS synchronous machines. The design details and experimental results are shown together with discussions about their implication for scaled up HTS machines.

**General information**
State: Published
Organisations: Department of Electrical Engineering, Electric Components, Materials Research Division, Nano-Microstructures in Materials, Rise National Laboratory for Sustainable Energy, Dynamical systems, Department of Mathematics
Publication date: 2011

**Publication information**
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
HTS_machine_laboratory_prototype_1_1_.pdf
Source: orbit
Source-ID: 286177
Publication: Research › Sound/Visual production (digital) – Annual report year: 2011

**Influence of Rare Earth Element Supply on Future Offshore Wind Turbine Generators**
Rare-earth elements have become very valuable to many industries, including the renewable energy industry. As their usage has spread, their demand has increased dramatically. At present, the vast majority of rare earth elements are mined in China. China is also the world’s leading consumer of rare earth material, and there are indications that Chinese
rare earth exports will decrease in the near future as China seeks to maintain a sufficient supply of these materials. The magnetic properties of some particular rare-earth elements have made them very useful in producing high power density electrical machines. Such machines are utilized in applications such as electric cars, and wind turbines. This paper will examine the rare earth supply issue, in order to comment on its relevance to the wind turbine industry. The wind turbine topologies which are currently being used are compared, highlighting their advantages and disadvantages in serving as long term solutions for offshore wind farms. Finally, a direct drive induction generator and a high temperature superconducting generator topology, which respectively are not and very little dependent on rare earth elements, are presented as candidates for use in future offshore wind turbines.

**General information**
State: Published
Organisations: Electric Components, Department of Electrical Engineering, Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Center for Electric Power and Energy
Authors: Jensen, B. B. (Intern), Abrahamsen, A. B. (Intern), Henriksen, M. L. (Intern)
Number of pages: 420
Pages: 227-237
Publication date: 2011

**Host publication information**
Title of host publication: Energy Systems and Technologies for the coming Century : Proceedings
Place of publication: Roskilde
Publisher: Risø National Laboratory for Sustainable Energy
Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1776(EN)
Main Research Area: Technical/natural sciences
Conference: Risø International Energy Conference 2011, Roskilde, Denmark, 10/05/2011 - 10/05/2011
Offshore wind energy, Risø-R-1776(EN), Risø-R-1776
Electronic versions: ris-r-1776.pdf
Source: orbit
Source-ID: 276648
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

**In-situ synchrotron x-ray study of the crystallization behavior of Ce₀.₉La₀.₁O₂₋ₓ thin films deposited on NiW alloy substrates by chemical solution method**
The phase and texture formation of La doped CeO2 (CLO) films deposited by the chemical solution method are studied by in situ synchrotron x-ray diffraction. It is found that the CLO crystallites forms excellent in-plane texture as soon as the phase appears at 860°C, indicating that interfacial nucleation dominates at the beginning of the amorphous–crystallization transition. Grain growth is almost complete after at 900°C for 15min. Analysis of the isothermal process of crystallization at 900°C by the Johnson–Mehl–Avrami–Kolmogorov equation shows that grain development is mainly controlled by diffusion. The success of this work demonstrates the possibility of studying crystallization behaviors of solution derived films using a non-destructive method, which has the potential of being applicable to most types of thin film samples.

**General information**
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Deutsches Elektronen-Synchrotron
Authors: Yue, Z. (Intern), Grivel, J. (Intern), Abrahamsen, A. B. (Intern), Pallewatta, P. G. A. P. (Intern), He, D. (Intern), Bednarčík, J. (Ekstern), Zimmermann, M. (Ekstern)
Pages: 2669-2672
Publication date: 2011
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Materials Letters
Volume: 65
Issue number: 17-18
ISSN (Print): 0167-577X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Minimising the Usage of Superconducting Tape in Electrical Machine Applications

General information
State: Published
Organisations: Department of Electrical Engineering, Electric Components, Wind Energy Systems, Department of Wind Energy
Modelling, Construction, and Testing of a Simple HTS Machine Demonstrator

This paper describes the construction, modeling and experimental testing of a high temperature superconducting (HTS) machine prototype employing second generation (2G) coated conductors in the field winding. The prototype is constructed in a simple way, with the purpose of having an inexpensive way of validating finite element (FE) simulations and gaining a better understanding of HTS machines. 3D FE simulations of the machine are compared to measured current vs. voltage (IV) curves for the tape on its own. It is validated that this method can be used to predict the critical current of the HTS tape installed in the machine. The measured torque as a function of rotor position is also reproduced by the 3D FE model.

Preparation of a Novel Ce$_{0.9}$La$_{0.1}$O$_2$/Gd$_2$Zr$_2$O$_7$ Buffer Layer Stack on NiW Alloy Substrates by the MOD Route

An optimized buffer layer architecture prepared by a metal organic deposition method on biaxially textured metallic substrate is proposed and developed successfully. The major achievement of this work is to choose a NiW Ce$_{0.9}$La$_{0.1}$O$_2$ layer as cap layer that possesses an excellent lattice match with the superconductor layer, and to employ 200 nm thick Gd$_2$Zr$_2$O$_7$ film as barrier layer. The effect of thermal cycling on the texture and morphology of the crystallized films and NiW substrate is discussed in detail. The texture quality and the epitaxial relationship between the buffer layer stack and the metallic substrate were studied by synchrotron x-ray diffraction. Well textured, smooth and crack-free buffer layer stacks are obtained, demonstrating the possibility of producing a high quality buffer layer stack by a low cost chemical solution deposition route.
**Simulation of an HTS Synchronous Superconducting Generator**

In this work we present a simulation of a synchronous generator with superconducting rotor windings. As many other electrical rotating machines, superconducting generators are exposed to ripple fields that could be produced from a wide variety of sources: short circuit, load change, etc. Unlike regular conductors, superconductors, experience high losses when exposed to AC fields. Thus, calculation of such losses is relevant for machine design to avoid quenches and increase performance. Superconducting coated conductors are well known to exhibit nonlinear resistivity, thus making the computation of heating losses a cumbersome task. Furthermore, the high aspect ratio of the superconducting materials involved adds a penalty in the time required to perform simulations. The chosen strategy for simulation is as follows: A mechanical torque signal together with an electric load is used to drive the finite element model of a synchronous generator where the current distribution in the rotor windings is assumed uniform. Then, a second finite element model for the superconducting material is linked to calculate the actual current distribution in the windings of the rotor. Finally, heating losses are computed as a response to both the driving mechanical input and the electric load change. The model is used to evaluate the effect of including a damper cage as a protection in the event of a short circuit in the stator coils.

**General information**
State: Published
Organisations: Dynamical systems, Department of Mathematics, Materials Research Division, Nano-Microstructures in Materials, Risø National Laboratory for Sustainable Energy, Department of Electrical Engineering, Electric Components
Authors: Rodriguez Zermeno, V. M. (Intern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Sørensen, M. P. (Intern), Jensen, B. B. (Intern), Pedersen, N. F. (Intern)
Publication date: 2011

**Publication information**
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 284799
Publication: Research › Sound/Visual production (digital) – Annual report year: 2011

**Superconducting generators for direct drive wind turbines**

**General information**
State: Published
Organisations: Department of Electrical Engineering, Electric Components, Risø National Laboratory for Sustainable Energy, Materials Research Division, Nano-Microstructures in Materials
Authors: Jensen, B. B. (Intern), Abrahamsen, A. B. (Intern)
Publication date: 2011

**Publication information**
Original language: English
Main Research Area: Technical/natural sciences
Links: http://www.wind-drivetrain.com/presentations
Source: orbit
Source-ID: 286173
Publication: Research › Sound/Visual production (digital) – Annual report year: 2011

**Superconducting Machines at the Technical University of Denmark**

Two high temperature superconducting (HTS) machine prototypes constructed at the Technical University of Denmark are presented. The construction process is presented and the excellent agreement between simulation results and experimental results are presented for one of the prototypes.

**General information**
State: Published
Organisations: Department of Electrical Engineering, Electric Components, Risø National Laboratory for Sustainable Energy, Materials Research Division, Nano-Microstructures in Materials
Authors: Jensen, B. B. (Intern), Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Træholt, C. (Intern)
Publication date: 2011

**Host publication information**
Towards Faster FEM Simulation of Thin Film Superconductors: A Multiscale Approach

This work presents a method to simulate the electromagnetic properties of superconductors with high aspect ratio such as the commercially available second generation superconducting YBCO tapes. The method is based on a multiscale representation for both thickness and width of the superconducting domains. A couple of test cases were successfully simulated and further investigations were made by means of structured (mapped) meshes. Here, large aspect ratio elements were used to simulate thin material layers with a reduced number of elements. Hence, more complex geometries can be studied at considerable lower computational time. Several test cases were simulated including transport current, externally applied magnetic field and a combination of both. The results are in good agreement with recently published numerical simulations. The computational time to solve the present multiscale approach in 2D is estimated as two orders of magnitude faster than other 2D methods.
AC loss in superconducting wires operating in a wind turbine like generator

We have manufactured a small circular superconducting coil impregnated with epoxy fibreglass. The coil was wound from a Bi-2223/Ag superconducting wire and it was tested in liquid nitrogen at 77 K. Current-voltage characteristic and the AC losses of the coil were measured and compared with the measurements on the original tape. The AC losses of the coil are approximately 10 times higher than the losses of the tape and they have been measured in two different experimental arrangements, one with directly connected and the other with transformer coupled power supply. Measurements in both arrangements resulted in the same AC loss characteristic. This work was done as a part of the Superwind project which aims to build a series of test coils and a spinning model of a generator to investigate AC loss and stability of the coils in wind turbine like conditions.
Anisotropy of the critical current in MgB$_2$ tapes made of high energy milled precursor powder

For applications of MgB$_2$ wires or tapes, high critical currents in high magnetic fields are essential. By using tapes in superconducting coils the anisotropic behaviour of the critical current, i.e. the dependence on the direction of the external field in relation to the tape surface, has to be taken into account. The anisotropy of MgB$_2$ tapes with mechanically alloyed (MA) precursor powder and different sheath materials which can be much higher than the intrinsic anisotropy is discussed. Furthermore tapes with pure and C doped MA-MgB$_2$ precursor are compared. Tapes with a hard Fe-sheath and undoped precursor show a high extrinsic anisotropy of the critical current density which can be reduced considerably by carbon doping. A texture of the MgB$_2$ phase in the tape filaments introduced by flat rolling was observed by synchrotron x-ray diffraction. Using this texture information the observed macroscopic Ic-anisotropy of the tapes can be explained by calculations based on the percolation model.

General information
State: Published
Coil Optimization for HTS Machines

An optimization approach of HTS coils in HTS synchronous machines (SM) is presented. The optimization is aimed at high power SM suitable for direct driven wind turbines applications. The optimization process was applied to a general radial flux machine with a peak air gap flux density of ~3T. The proposed coil design is optimized with respect to minimizing the perpendicular field while still maximizing the amplitude of fundamental space harmonic. This guarantees the lowest HTS loss density and best utilization of expensive HTS material in the field winding of the SM. Additionally, accounting for different tape parameters $I_{ci}$, $n_i$ and $C_i$, where $I_{ci}$, $n_i$ and $C_i$ are critical current, $n$ - value and price of the $i$th tape respectively and $i=1, 2, 3…$, further optimization with respect to cost vs. HTS losses has been performed. Allowing for different types of HTS tapes in the coils, a guidance to which tape is suitable for which coil segment is presented. Thus, the performed study gives valuable input for the coil design of HTS machines ensuring optimal usage of HTS tapes.

High energy synchrotron X-ray diffraction studies of lithium batteries

High energy synchrotron X-ray diffraction studies of lithium batteries

Influence of the initial Bi2223 phase content on microstructure development in Bi2223/Ag tapes

Influence of the initial Bi2223 phase content on microstructure development in Bi2223/Ag tapes

(Bi,Pb)2Sr2Ca2Cu3O10 (Bi2223) Ag-sheathed tapes were produced from precursors containing various amounts of pre-reacted Bi2223 phase obtained by means of controlled calcinations of the starting powder mixture. The evolution of the
critical current density during the first 20h of the first heat treatment follows closely that of the Bi2223 phase content. A maximum rate of increase is observed for precursor powders initially containing a small amount of Bi2223. The crystallinity of the Bi2223 phase along its c-axis improves with sintering time and is better in the tapes manufactured with precursor powders containing the largest amount of prereacted Bi2223. While the degree of preferential orientation of the Bi2223 phase at the Ag/ceramic core interface is not influenced by the initial Bi2223 phase content, the average texture in the ceramic core worsens with the increase of initial Bi2223 phase content. This effect is likely to play a role in the limited performance of Bi2223-rich precursors.

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Tsinghua University, Deutsches Elektronen-Synchrotron
Authors: Grivel, J. (Intern), Yang, X. P. (Ekstern), Abrahamsen, A. B. (Intern), Han, Z. (Ekstern), Andersen, N. H. (Intern), von Zimmermann, M. (Ekstern)
Pages: 022012
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 234
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Multi-Pole HTS Generators for Direct Drive Wind Turbines
In this presentation the feasibility of installing a 5MW direct drive superconducting generator for an offshore wind turbine is presented. The reference turbine is a geared 5MW wind turbine that has been installed offshore and has been documented extensively by the National Renewable Energy laboratory (NREL). The emphasis of the investigation is on cost and mass, where the cost limit for the active material is set at €1M; the active mass limit is set at 40 tons; and the outer diameter is 4.2 meters. The allowable engineering current densities have been estimated by measuring the magnetization on two different types of coated conductor. In the specific design the allowable current density was 300A/mm² for tape 1 and 70A/mm² for tape 2. The design is analytical, based on magnetic circuit analysis, which is validated by finite element modelling. The conclusion is that the either price or the performance of the coated conductor has to improve significantly (by a factor of 10 or more) in order for HTS generators to become feasible in direct drive offshore wind turbines. This price/performance improvement is not unrealistic in the coming decade. Additionally the reliability of such machines will have to be demonstrated.

Superconducting Generator for Wind Turbines – Possible Nacelle Mass Reductions for Direct Drive Offshore Turbines

Superconducting generators for wind turbines: design considerations
The harmonic content of high temperature superconductors (HTS) field winding in air-core high temperature superconducting synchronous machine (HTS SM) has been addressed in order to investigate tendency of HTS SM towards mechanical oscillation and additional loss caused by higher flux harmonic. Both analytical expressions for flux distribution and current sheet distribution have been derived and analyzed. The two main contributors to the AC loss of HTS rotor winding are also identified and their influence addressed on general level.
Superconducting wind turbine generators

We have examined the potential of 10 MW superconducting direct drive generators to enter the European offshore wind power market and estimated that the production of about 1200 superconducting turbines until 2030 would correspond to 10% of the EU offshore market. The expected properties of future offshore turbines of 8 and 10 MW have been determined from an up-scaling of an existing 5 MW turbine and the necessary properties of the superconducting drive train are discussed. We have found that the absence of the gear box is the main benefit and the reduced weight and size is secondary. However, the main challenge of the superconducting direct drive technology is to prove that the reliability is superior to the alternative drive trains based on gearboxes or permanent magnets. A strategy of successive testing of superconducting direct drive trains in real wind turbines of 10 kW, 100 kW, 1 MW and 10 MW is suggested to secure the accumulation of reliability experience. Finally, the quantities of high temperature superconducting tape needed for a 10 kW and an extreme high field 10 MW generator are found to be 7.5 km and 1500 km, respectively. A more realistic estimate is 200–300 km of tape per 10 MW generator and it is concluded that the present production capacity of coated conductors must be increased by a factor of 36 by 2020, resulting in a ten times lower price of the tape in order to reach a realistic price level for the superconducting drive train.

General information

State: Published
Number of pages: 8
Pages: 034019
Publication date: 2010
Main Research Area: Technical/natural sciences

Publication information

Journal: Superconductor Science & Technology
Volume: 23
Issue number: 3
ISSN (Print): 0953-2048
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.426 SJR 1.036 CiteScore 2.63
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.07 SJR 0.967 SNIP 1.45
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 1.13 SNIP 1.603 CiteScore 2.08
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.196 SNIP 1.356 CiteScore 1.71
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.318 SNIP 1.599 CiteScore 1.78
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.535 SNIP 1.458 CiteScore 1.66
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.461 SNIP 1.363 CiteScore 2.4
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Superconducting wind turbine generators

General information
State: Published
Authors: Abrahamsen, A. B. (Intern), Jensen, B. B. (Intern), Seiler, E. (Intern), Mijatovic, N. (Intern), Andersen, N. H. (Intern), Østergaard, J. (Intern)
Publication date: 2010
Event: Abstract from 23rd International Symposium on Superconductivity 2010, Tsukuba (JP), 1-3 Nov,
Main Research Area: Technical/natural sciences
Materials and energy storage, Superconducting materials
Source: orbit
Source-ID: 272650
Publication: Research › Conference abstract for conference – Annual report year: 2010

Superconducting wind turbines

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Materials Research Division, Nano-Microstructures in Materials, Department of Electrical Engineering, Electric Components, Electric Energy Systems Programme, Composites and Materials Mechanics, Department of Physics, Quantum Physics and Information Technology, Department of Mathematics, Dynamical systems, Electric Energy Systems
Texture induced anisotropy of critical current of MgB$_2$/Fe rolled superconducting tapes studied by synchrotron x-ray diffraction

General information
State: Published
Authors: Abrahamsen, A. B. (Intern), Häßler, W. (Ekstern), Kovac, P. (Ekstern), Eisterer, M. (Ekstern), Herrmann, M. (Ekstern), Rodig, C. (Ekstern), Henkov, K. (Ekstern), Holzapfel, B. (Ekstern), Melisek, T. (Ekstern), Kulich, M. (Ekstern), von Zimmermann, M. (Ekstern), Bednarcik, J. (Ekstern), Grivel, J. (Intern)
Publication date: 2010
Event: Poster session presented at 40th Danish Crystallographers Meeting and 3rd DANSCATT Meeting, Copenhagen, Denmark.
Main Research Area: Technical/natural sciences
Materials and energy storage, Superconducting materials
Electronic versions: ABAbrahamsen_Danscatt.pdf
Source: orbit
Source-ID: 272676
Publication: Research › Poster – Annual report year: 2010

Towards faster FEM simulation of thin film superconductors

General information
State: Published
Organisations: Electric Components, Department of Electrical Engineering, Dynamical systems, Department of Mathematics, Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Publication date: 2010
Event: ECMI 2010 Conference, Wuppertal, Germany, 01/01/2010
Main Research Area: Technical/natural sciences
Materials and energy storage, Superconducting materials
Host publication information
Title of host publication: ECMI 2010 Conference
Conference: ECMI 2010 Conference, Wuppertal, Germany, 01/01/2010
Materials and energy storage, Superconducting materials
Source: orbit
Source-ID: 271057
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Defining B-c, B* and B-phi for YBCO Thin Films

The accommodation field, B*, is generally defined to be the field at which the cross over from single vortex pinning to collective pinning occurs. It is determined from magnetization curves as the point where the J_c plateau ends and it used as a convenient way of comparing the pinning properties of superconducting films. Similarly, the characteristic field, B_c, can be obtained from magneto-optical (MO) images from when the flux fronts meet in the middle of the film. The matching field, B phi, at which there is one vortex line per pinning site, is sometimes thought to be the same as B*, but in BaZrO3-doped YBa2Cu3O7 films the calculated B phi is much higher than the observed B*. B phi can be determined from angular dependent transport measurements. All of the field values correspond to some special case in the flux pinning in the film and relate to J_c. In this work we have determined B c, B* and B phi for different kinds of YBCO films using MO, magnetization and transport measurements to reveal the deeper meaning of the special fields.

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, University of Turku
Authors: Paturi, P. (Ekstern), Irjala, M. (Ekstern), Abrahamsen, A. B. (Intern), Huhtinen, H. (Ekstern)
Pages: 3431-3434
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Applied Superconductivity
Volume: 19
Issue number: 3
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.555 SNIP 1.274 CiteScore 1.11
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.368 SNIP 1.062 CiteScore 1.16
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.473 SNIP 1.065
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.447 SNIP 1.021
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.884 SNIP 0.981
Scopus rating (2007): SJR 0.629 SNIP 1.093
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.734 SNIP 1.05
Scopus rating (2005): SJR 0.652 SNIP 0.992
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.882 SNIP 0.904
Scopus rating (2003): SJR 0.51 SNIP 1.054
Web of Science (2003): Indexed yes
Scopus rating (2002): SJR 1.226 SNIP 1.024
Scopus rating (2001): SJR 0.552 SNIP 1.368
Design study of 10 kW superconducting generator for wind turbine applications

We have performed a design study of a 10 kW superconducting slow rotating generator suitable for demonstration in a small scale wind turbine, where the drive train only consists of the turbine blades connected directly to the generator. The flux density in the superconducting rotor is chosen as \( B = 1 \) Tesla to be similar to the performance of permanent magnets and to represent a layout, which can be scaled up in future off-shore wind turbines. The proposed generator is a 8 pole synchronous machine based on race-track coils of high temperature superconducting tapes and an air cored copper stator enclosed in an iron shield.

General information

State: Published
Authors: Abrahamsen, A. B. (Intern), Mijatovic, N. (Intern), Seiler, E. (Intern), Sørensen, M. P. (Intern), Koch, M. (Intern), Nørgård, P. B. (Intern), Pedersen, N. F. (Intern), Træholt, C. (Intern), Andersen, N. H. (Intern), Østergaard, J. (Intern)
Pages: 1678-1682
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information

Journal: IEEE Transactions on Applied Superconductivity
Volume: 19
Issue number: 3
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
Fast 2D Simulation of Superconductors: a Multiscale Approach

This work presents a method to calculate AC losses in thin conductors such as the commercially available second generation superconducting wires through a multiscale meshing technique. The main idea is to use large aspect ratio elements to accurately simulate thin material layers. For a single thin superconductor, several standard test cases are simulated including transport current, externally applied magnetic field and a combination of both. The results are in good agreement with recently published numerical simulations and show even faster time to solution. A couple of examples involving several thin conductors in different circumstances are also shown.

General information
State: Published
Organisations: Dynamical systems, Department of Mathematics, Electric Components, Department of Electrical Engineering, Nano-Microstructures in Materials, Materials Research Division, Rise National Laboratory for Sustainable Energy
Fermi Surface and Order Parameter Driven Vortex Lattice Structure Transitions in Twin-Free YBa2Cu3O7

We report on small-angle neutron scattering studies of the intrinsic vortex lattice (VL) structure in detwinned YBa2Cu3O7 at 2 K, and in fields up to 10.8 T. Because of the suppressed pinning to twin-domain boundaries, a new distorted hexagonal VL structure phase is stabilized at intermediate fields. It is separated from a low-field hexagonal phase of different orientation and distortion by a first-order transition at 2.0(2) T that is probably driven by Fermi surface effects. We argue that another first-order transition at 6.7(2) T, into a rhombic structure with a distortion of opposite sign, marks a crossover from a regime where Fermi surface anisotropy is dominant, to one where the VL structure and distortion is controlled by the order-parameter anisotropy.

General information
- State: Published
- Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, University of Birmingham, Max Planck Institute, Universität Zürich, National Institute of Standards and Technology, Institut Laue-Langevin, Paul Scherrer Institut, Walther-Meissner-Institut
- Authors: White, J. (Ekstern), Hinkov, V. (Ekstern), Heslop, R. (Ekstern), Lycett, R. (Ekstern), Forgan, E. (Ekstern), Bowell, C. (Ekstern), Strässle, S. (Ekstern), Abrahamsen, A. B. (Intern), Laver, M. (Ekstern), Dewhurst, C. (Ekstern), Kohlbrecher, J. (Ekstern), Gavilano, J. (Ekstern), Mesot, J. (Ekstern), Keimer, B. (Ekstern), Erb, A. (Ekstern)
- Pages: 097001
- Publication date: 2009
- Main Research Area: Technical/natural sciences

Publication information
- Journal: Physical Review Letters
- Volume: 102
- Issue number: 9
- ISSN (Print): 0031-9007
- Ratings:
  - BFI (2018): BFI-level 2
  - Web of Science (2018): Indexed yes
  - BFI (2017): BFI-level 2
  - Scopus rating (2017): CiteScore 7.58 SJR 3.622 SNIP 2.464
  - Web of Science (2017): Indexed yes
  - BFI (2016): BFI-level 2
  - Scopus rating (2016): CiteScore 6.33 SJR 4.196 SNIP 2.61
  - Web of Science (2016): Indexed yes
  - BFI (2015): BFI-level 2
  - Scopus rating (2015): SJR 4.656 SNIP 2.538 CiteScore 5.76
  - Web of Science (2015): Indexed yes
  - BFI (2014): BFI-level 2
  - Scopus rating (2014): SJR 5.232 SNIP 2.71 CiteScore 6.62
Modeling flux pinning in thin undoped and BaZrO3-doped YBCO films
A simple model based on distributions of twin boundaries, dislocations, and BaZrO3 nanorods is presented to describe the Jc properties of undoped and BaZrO3 (BZO)-doped YBa2Cu3Ox thin films. The model accurately describes the shape of Jc(B,T) curves of the films, when the pinning site distributions are taken from distributions of twin spacings and BZO nanorods from transmission electron microscope images. Thus, assuming that the model can be used for prediction of the Jc properties, we conclude that for enhancement of undoped films more crystalline defects are needed and for doped films a dopant that would create slightly larger rods would be optimal. ©2009 American Institute of Physics

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, University of Turku
Authors: Paturi, P. (Ekstern), Irjala, M. (Ekstern), Huhtinen, H. (Ekstern), Abrahamsen, A. B. (Intern)
Pages: 023904
Publication date: 2009
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Applied Physics
Volume: 105
Issue number: 2
ISSN (Print): 0021-8979
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.953 SJR 0.739 CiteScore 2.03
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.72 SJR 0.906 SNIP 0.977
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.821 SNIP 0.996 CiteScore 1.57
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.039 SNIP 1.197 CiteScore 2.04
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.155 SNIP 1.286 CiteScore 2.24
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.312 SNIP 1.291 CiteScore 2.13
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.374 SNIP 1.3 CiteScore 2.24
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.484 SNIP 1.204
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.51 SNIP 1.237
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.644 SNIP 1.326
Web of Science (2008): Indexed yes
Structure and degeneracy of vortex lattice domains in pure superconducting niobium: A small-angle neutron scattering study

High-purity niobium exhibits a surprisingly rich assortment of vortex lattice (VL) structures for fields applied parallel to a fourfold symmetry axis, with all observed VL phases made up of degenerate domains that spontaneously break some crystal symmetry. Yet a single regular hexagonal VL domain is observed at all temperatures and fields parallel to a threefold symmetry axis. We report a detailed investigation of the transition between these lush and barren VL landscapes, discovering new VL structures and phase transitions at high fields. We show that the number and relative population of VL domains is intrinsically tied to the underlying crystal symmetry. We discuss how subtle anisotropies of the crystal may generate the remarkable VLs observed.
Superconducting generators for wind turbines

General information
State: Published
Organisations: Electric Components, Department of Electrical Engineering, Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Department of Mathematics
Publication date: 2009

Host publication information
Title of host publication: Future Energy - Bornholm
Publisher: IDA, Steering Group on Future Energy - Bornholm
Main Research Area: Technical/natural sciences
Materials and systems for energy storage, Wind energy
Source: orbit
Source-ID: 252334
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Avoided crossing of rattler modes in thermoelectric materials
Engineering of materials with specific physical properties has recently focused on the effect of nano-sized 'guest domains' in a 'host matrix' that enable tuning of electrical, mechanical, photo-optical or thermal properties. A low thermal conductivity is a prerequisite for obtaining effective thermoelectric materials, and the challenge is to limit the conduction of heat by phonons, without simultaneously reducing the charge transport. This is named the 'phonon glass-electron crystal' concept and may be realized in host-guest systems. The guest entities are believed to have independent oscillations, so-called rattler modes, which scatter the acoustic phonons and reduce the thermal conductivity. We have investigated the phonon dispersion relation in the phonon glass-electron crystal material Ba8Ga16Ge30 using neutron triple-axis spectroscopy. The results disclose unambiguously the theoretically predicted avoided crossing of the rattler modes and the acoustic-phonon branches. The observed phonon lifetimes are longer than expected, and a new explanation for the low k(L) is provided.

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Thermo Ceramics, Fuel Cells and Solid State Chemistry Division, Aarhus University, Swiss Federal Institute of Technology, Chalmers University of Technology
Authors: Christensen, M. (Ekstern), Abrahamsen, A. B. (Intern), Christensen, N. B. (Intern), Juranyi, F. (Ekstern), Andersen, N. H. (Intern), Lefmann, K. (Intern), Andreasson, J. (Ekstern), Bahl, C. R. H. (Intern), Iversen, B. B. (Ekstern)
Pages: 811-815
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Nature Materials
Volume: 7
Issue number: 10
ISSN (Print): 1476-1122
Ratings:
BFI (2018): BFI-level 3
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): SJR 18.263 SNIP 8.977 CiteScore 25.47
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 23.67 SJR 18.013 SNIP 9.04
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Design study of superconducting 10 kW demonstration generator for wind turbine applications

General information
State: Published
Number of pages: 413
Pages: 199-206
Publication date: 2008

Host publication information
Effects of Cu or Ag additions on the kinetics of MgB$_2$ phase formation in Fe-sheathed wires

MgB$_2$/Fe wires have been produced by the powder-in-tube technique following the in situ route. The influence of low amounts of Cu or Ag additions into the precursor powder mixture on the kinetics of MgB$_2$ formation was studied in situ by means of synchrotron x-ray diffraction during heat-treatments at 504 and 547 degrees C. Both Cu and Ag additions result in a significant increase of the MgB$_2$ formation rate. A thin, discontinuous Fe$_2$B layer was formed at the interface between the MgB$_2$ core and the Fe sheath. At the end of the heat-treatment, Cu and Ag were found in submicrometer-sized particles segregated within the MgB$_2$ matrix.
FEM: a tool for designing a superconducting generator for a wind turbine

General information
State: Published
Organisations: Electric Power Engineering, Department of Electrical Engineering, Dynamical systems, Department of Mathematics, Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Authors: Mijatovic, N. (Intern), Sørensen, M. P. (Intern), Abrahamsen, A. B. (Intern), Træholt, C. (Intern), Pedersen, N. F. (Intern)
Number of pages: 315
Publication date: 2008

Host publication information
Title of host publication: Proceedings of the 29th International Symposium on Materials science
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 224582
Publication: Research › Article in proceedings – Annual report year: 2008

In-situ synchrotron X-ray study of MgB₂ formation when doped by SiC

General information
State: Published
Manufacture of (Bi,Pb)$_2$Sr$_2$Ca$_2$Cu$_3$O$_{10}$-based tapes with a composite sheath

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy, Hamburger Synchrotronstrahlungslabor
Authors: Grivel, J. (Intern), Abrahamsen, A. B. (Intern), Andersen, N. H. (Intern), Saksl, K. (Ekstern)
Pages: 012033
Publication date: 2008
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Physics: Conference Series (Online)
Volume: 97
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.258 SNIP 0.399
Web of Science (2007): Indexed yes
Scopus rating (2006): SJR 0.272 SNIP 0.311
Web of Science (2006): Indexed yes
Original language: English
DOIs:
10.1088/1742-6596/97/1/012033
Superconductor based energy production

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. B. (Intern)
Pages: 131-150
Publication date: 2008

Host publication information
Title of host publication: Materialer og energi
Place of publication: Lyngby
Publisher: DMS
Editor: Brøndsted, P.
ISBN (Print): 87-87535-38-6
Main Research Area: Technical/natural sciences
Conference: Roskilde, Denmark, 01/01/2008
Source: orbit
Source-ID: 223176
Publication: Research › Article in proceedings – Annual report year: 2008

Synchrotron radiation: A powerful tool for probing superconducting/metal composite wires and tapes

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Materials Research Division, Nano-Microstructures in Materials, Metal Structures in Four Dimensions, Deutsches Elektronen-Synchrotron
Authors: Grivel, J. (Intern), Abrahamsen, A. B. (Intern), Andersen, N. H. (Intern), Poulsen, H. F. (Intern), Homeyer, J. (Ekstern), Saksl, K. (Ekstern), Bednarcik, J. (Ekstern), v. Zimmermann, M. (Ekstern)
Number of pages: 413
Pages: 47-63
Publication date: 2008

Host publication information
Place of publication: Roskilde
Publisher: Danmarks Tekniske Universitet, Risø Nationallaboratoriet for Bæredygtig Energi
ISBN (Print): 978-87-550-3694-9
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 222829
Publication: Research › peer-review › Article in proceedings – Annual report year: 2008

Uncovering flux line correlations in superconductors by reverse monte carlo refinement of neutron scattering data

We describe the use of reverse Monte Carlo refinement to extract structural information from angle-resolved data of a Bragg peak. Starting with small-angle neutron scattering data, the positional order of an ensemble of flux lines in superconducting Nb is revealed. We discuss the uncovered correlation functions in the light of topical theories, in particular, the "Bragg glass" paradigm.

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Authors: Laver, M. (Ekstern), Forgan, E. (Ekstern), Abrahamsen, A. B. (Intern), Bowell, C. (Ekstern), Geue, T. (Ekstern), Cubitt, R. (Ekstern)
Kinetics of MgB$_2$ formation studied by in-situ synchrotron X-ray powder diffraction

**General information**

State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. B. (Intern), Grivel, J. (Intern), Andersen, N. H. (Intern), Homeyer, J. (Ekstern), Saksl, K. (Ekstern)
Pages: 2757-2760
Publication date: 2007
Main Research Area: Technical/natural sciences

**Publication information**

Journal: IEEE Transactions on Applied Superconductivity
Volume: 17
ISSN (Print): 1051-8223
Ratings:
- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
Kvantetornadoer i superledere studeret med neutroner

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. B. (Intern)
Pages: 24-25
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication information
Journal: Kvant
Volume: 18
Issue number: 2
ISSN (Print): 0905-8893
Ratings:
ISI indexed (2013): ISI indexed no
ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 216324
Publication: Communication › Journal article – Annual report year: 2007
Pauli paramagnetic effects on vortices in superconducting TmNi2B2C

The magnetic field distribution around the vortices in TmNi2B2C in the paramagnetic phase was studied experimentally as well as theoretically. The vortex form factor, measured by small-angle neutron scattering, is found to be field independent up to 0.6H(c2) followed by a sharp decrease at higher fields. The data are fitted well by solutions to the Eilenberger equations when paramagnetic effects due to the exchange interaction with the localized 4f Tm moments are included. The induced paramagnetic moments around the vortex cores act to maintain the field contrast probed by the form factor.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy, Nano-Microstructures in Materials, Materials Research Division
Number of pages: 4
Pages: 167001
Publication date: 2007
Main Research Area: Technical/natural sciences

Publication Information
Journal: Physical Review Letters
Volume: 99
Issue number: 16
ISSN (Print): 0031-9007
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.58 SJR 3.622 SNIP 2.464
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 6.33 SJR 4.196 SNIP 2.61
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 4.656 SNIP 2.538 CiteScore 5.76
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 5.232 SNIP 2.71 CiteScore 6.62
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 5.675 SNIP 2.781 CiteScore 7.46
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): SJR 6.292 SNIP 2.867 CiteScore 7.19
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): SJR 6.314 SNIP 2.905 CiteScore 7.02
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 2
Scopus rating (2010): SJR 6.45 SNIP 2.757
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 2
Scopus rating (2009): SJR 6.325 SNIP 2.947
Web of Science (2009): Indexed yes
Pauli paramagnetic effects on vortices in superconducting TmNi2B2C

General information
State: Published
Organisations: Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Publication date: 2007
Event: Abstract from 3rd Annual meeting Danish Physical Society, Nyborg, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 216247
Publication: Research › Conference abstract for conference – Annual report year: 2007

The phase diagram of YBCo nano-particles

General information
State: Published
Authors: Hjöllum, J. Í. (Intern), Kuhn, L. (Intern), Lefmann, K. (Intern), Niedermayer, C. (Ekstern), Raittila, J. (Ekstern), Andersen, N. H. (Intern), Abrahamsen, A. B. (Intern), Grivel, J. (Intern), Lebech, B. (Intern), Christensen, N. B. (Intern), Paturi, P. (Intern)
Publication date: 2007
Combined X-ray and electron microscopy study of MgB$_2$ powders, wires and tapes

**General information**

State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 107-110
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Journal of Physics: Conference Series (Online)
Volume: 43
ISSN (Print): 1742-6596
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 0.48 SJR 0.241 SNIP 0.447
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.45 SJR 0.24 SNIP 0.401
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.252 SNIP 0.374 CiteScore 0.35
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.264 SNIP 0.352 CiteScore 0.32
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.245 SNIP 0.293 CiteScore 0.25
ISI indexed (2013): ISI indexed no
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.293 SNIP 0.387 CiteScore 0.33
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.293 SNIP 0.356 CiteScore 0.43
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.288 SNIP 0.351
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.259 SNIP 0.346
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.264 SNIP 0.301
Design of MgB$_2$ superconducting dipole magnet for particle beam transport in accelerators

**General information**

State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. (Intern), Zangenberg, N. (Ekstern), Baurichter, A. (Ekstern), Grivel, J. (Intern), Andersen, N. H. (Intern)
Number of pages: 14
Publication date: 2006

**Publication information**

ISBN (Print): 87-550-3555-8
Original language: English

Series: Denmark. Forskningscenter Risoe. Risoe-R
Number: 1578(EN)
ISSN: 0106-2840
Main Research Area: Technical/natural sciences
Electronic versions:
ris_r_1578.pdf
Source: orbit
Source-ID: 309694
Publication: Research › Report – Annual report year: 2006

Effect of starting composition and annealing temperature on irreversibility field and critical current density in MgxB$_2$

Bulk samples of MgxB$_2$ with starting composition of 0.5 $\leq$ x $\leq$ 1.3 were prepared using a solid-state reaction route. Their structure and critical current density (J(c)) were investigated. The experimental results show that the starting composition MgxB$_2$, as well as the sintering temperature, has a significant influence on J(c) and H-irr. The lattice parameter a increases with x and c shows a maximum value around x = 0.9. All the samples possess a J(c) value about 10(6) A/cm(2) in self-field for x > 0.5. However, at high magnetic field the Mg-deficient samples exhibit higher J(c) values. The highest irreversibility field of H-irr = 5.2 T at 20 K was reached for x = 0.8 with sintering temperature of 800 degrees C, which is 0.8 T higher than that of the stoichiometric MgB$_2$ sample. It is suggested that the formation of MgB$_4$ nanoparticles is responsible for the increase of H-irr and J(c). (c) 2005 Published by Elsevier B.V.

**General information**

State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Xu, G. (Ekstern), Pinholt, R. (Intern), Bilde-Sørensen, J. (Intern), Grivel, J. (Intern), Abrahamsen, A. (Intern), Andersen, N. (Intern)
Pages: 67-70
Publication date: 2006
Main Research Area: Technical/natural sciences

**Publication information**

Journal: Physica C: Superconductivity and its Applications
Volume: 434
Issue number: 1
ISSN (Print): 0921-4534
Ratings:
BFI (2018): BFI-level 1
Inelastic neutron scattering experiments with the monochromatic imaging mode of the RITA-II spectrometer

Recently a monochromatic multiple data taking mode has been demonstrated for diffraction experiments using a RITA type cold neutron spectrometer with a multi-bladed analyser and a position-sensitive detector. Here, we show how this mode can be used in combination with a flexible radial collimator to perform real inelastic neutron scattering experiments. We present the results from inelastic powder, single crystal dispersion and single crystal constant energy mapping experiments. The advantages and complications of performing these experiments are discussed along with a comparison between the imaging mode and the traditional monochromatic focussing mode.

General information
State: Published
Organisations: Department of Physics, Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy
Pages: 452-462
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Nuclear Instruments & Methods in Physics Research Section B-beam Interactions With Materials and Atoms
Volume: 246
Issue number: 2
ISSN (Print): 0168-583X
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.36 SJR 0.558 SNIP 1.02
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.22 SJR 0.662 SNIP 0.911
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.722 SNIP 1.029 CiteScore 1.32
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.61 SNIP 0.882 CiteScore 1.14
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.678 SNIP 1.21 CiteScore 1.47
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.661 SNIP 0.992 CiteScore 1.18
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.703 SNIP 1.067 CiteScore 1.24
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.853 SNIP 0.971
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.68 SNIP 0.953
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Magnetic and quadrupolar ordering in TmNi$_2$B$_2$C

We present neutron and high-energy synchrotron X-ray diffraction studies to show that the anomalous antiferromagnetic (AF) phase diagram of TmNi$_2$B$_2$C in an applied field along [1 0 0] is governed by a quadrupolar ordering of the Tm ions. The ordering is revealed by a distortion of the lattice with the Tm ions displaced along the c-axis and modulated with the same wave vector $Q_A=(0.484, 0, 0)$ as the AF phase induced by fields larger than $\approx 10$ kOe. In zero field, the quadrupolar ordering temperature is $T_Q\approx 13.5$ K but increases to about 20 K in a field of 100 kOe. The Tm displacements are also significantly enhanced, by a factor of 10 at 60 kOe. A model is presented that accounts for the quadrupolar as well as the low-field $Q_F=(0.94, 0.94, 0)$ and high-field $Q_A=(0.483, 0, 0)$ AF ordering previously observed in this compound.

General information

State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 63-65
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Physica B: Condensed Matter
Volume: 385-386
Issue number: SI
ISSN (Print): 0921-4526
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.417 SNIP 0.791
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.39 SJR 0.446 SNIP 0.828
Web of Science (2016): Indexed yes
Neutron scattering investigations of the antiferromagnetic phase of YBCO nano-particles

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Hjøllum, J. I. (Ekstern), Kuhn, L. (Intern), Lefmann, K. (Intern), Abrahamsen, A. (Intern), Lebech, B. (Ekstern), Andersen, N. (Intern), Raittila, J. (Ekstern), Niedermayer, C. (Ekstern), Christensen, N. (Ekstern), Paturi, P. (Ekstern)
Publication date: 2006
Event: Abstract from Danish Physical Society Annual Meeting 2006, Nyborg, Denmark.
Main Research Area: Technical/natural sciences
Source: orbit
Phonon-induced quadrupolar ordering of the magnetic superconductor TmNi$_2$B$_2$C

We present synchrotron x-ray diffraction studies revealing that the lattice of thulium borocarbide is distorted below $T(Q) \approx 13.5$ K at zero field. $T-Q$ increases and the amplitude of the displacements is drastically enhanced by a factor of 10 at 60 kOe when a magnetic field is applied along [100]. The distortion occurs at the same wave vector as the antiferromagnetic ordering induced by the a-axis field. A model is presented that accounts for the properties of the quadrupolar phase and explains the peculiar behavior of the antiferromagnetic ordering previously observed in this compound.
Realizing the full potential of a RITA spectrometer

The "re-invented triple-axis spectrometer (RITA) concept has existed for a decade. Recent developments at RITA-2 at PSI, have revealed more of the potential of this instrument class. We demonstrate the performance of the multi-blade imaging mode, which has been applied e.g. to studies of dispersion relations and emphasize the power of this mode in combination with the low background of RITA-2. In addition, we present other ways of utilizing the position sensitive detector in a RITA instrument. Simulations of a planned upgrade of the guide-monochromator system at RITA-2 have shown a potential to increase the flux at the sample position by a factor 5.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 1083-1085
Publication date: 2006
Main Research Area: Technical/natural sciences

Publication information
Journal: Physica B: Condensed Matter
Volume: 385-386
Issue number: Part 2
ISSN (Print): 0921-4526
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.417 SNIP 0.791
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.39 SJR 0.446 SNIP 0.828
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.475 SNIP 0.809 CiteScore 1.41
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.549 SNIP 0.931 CiteScore 1.45
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Magnetic and quadrupolar ordering in TmNi$_2$B$_2$C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Number of pages: 221
Publication date: 2005

Host publication information
Title of host publication: Final programme and abstract book
Place of publication: Sydney
Publisher: ICNS
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308875
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2005
Magneto-elastic properties and quadrupolar ordering in the magnetic superconductor TmNi₂B₂C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Jensen, J. (Ekstern), Jensen, T. (Intern), Pinholt, R. (Intern), Andersen, N. (Intern), Zimmermann, M. V. (Ekstern), Abrahamsen, A. (Intern), Toft, K. (Ekstern), Hedegård, P. (Ekstern), Canfield, P. (Ekstern)
Publication date: 2005
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308075
Publication: Research › Conference abstract for conference – Annual report year: 2005

Neutron scattering investigations of the antiferromagnetic phase of YBCO nano-particles

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Hjøllum, J. (Ekstern), Kuhn, L. (Intern), Lefmann, K. (Intern), Abrahamsen, A. (Intern), Lebech, B. (Intern), Andersen, N. (Intern), Raittila, J. (Ekstern), Paturi, P. (Ekstern)
Number of pages: 222
Publication date: 2005
Host publication information
Title of host publication: Final programme and abstract book
Place of publication: Sydney
Publisher: ICNS
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308874
Publication: Research › Conference abstract in proceedings – Annual report year: 2005

Realizing the full potential of a RITA spectrometer

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Number of pages: 253
Publication date: 2005
Host publication information
Title of host publication: Final programme and abstract book
Place of publication: Sydney
Publisher: ICNS
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 308888
Publication: Research › Conference abstract in proceedings – Annual report year: 2005

The Rattler effect in thermoelectric materials

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Christensen, M. (Ekstern), Abrahamsen, A. (Intern), Juranyi, F. (Ekstern), Andersen, N. (Intern), Lefmann, K. (Intern), Bahl, C. (Intern), Iversen, B. (Ekstern)
Number of pages: 122
BixY3-xFe5O12 thin films prepared by laser ablation for magneto-optical imaging of superconducting thin films

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Laulajainen, M. (Ekstern), Paturi, P. (Ekstern), Raittila, J. (Ekstern), Huhtinen, H. (Ekstern), Abrahamsen, A. (Intern), Andersen, N. (Intern), Laiho, R. (Ekstern)
Pages: 218-223
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Magnetism and Magnetic Materials
Volume: 279
ISSN (Print): 0304-8853
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SJR 0.786 SNIP 1.349 CiteScore 2.97
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.41 SJR 0.699 SNIP 1.181
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.73 SNIP 1.296 CiteScore 2.33
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.815 SNIP 1.423 CiteScore 2.07
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.801 SNIP 1.385 CiteScore 2.03
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.928 SNIP 1.294 CiteScore 1.95
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.07 SNIP 1.275 CiteScore 1.84
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.936 SNIP 0.987
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Developments in neutron instrumentation for the study of magnetic nanoparticles

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 2004
Event: Abstract from Board meeting for the framework programme in nanomagnetism, Lyngby (DK), 25 Nov, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 307093
Publication: Research › Journal article – Annual report year: 2004

Enhancement of the irreversibility field in bulk MgB2 by TiO2 nanoparticle addition

MgB2 samples doped with TiO2 nanoparticles were prepared and the effect of TiO2 addition on the superconducting transition temperature (Tc), irreversibility field (H-irr) and critical current density (Jc) were investigated. It is found that the hexagonal lattice parameters a and c decrease with TiO2 doping. Tc decreases gradually from 38.2 to 37.8 K as the TiO2 content increases from 0 to 15 wt%. The H-irr increases at 20 K from 4.3 to 4.9 T as the TiO2 content increases from 0 to 10 wt%, and at the same temperature Jc increases from 450 to 4250 A/cm(2) at 4.2 T. (C) 2004 Published by Elsevier B.V.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Xu, G. (Ekstern), Grivel, J. (Intern), Abrahamsen, A. (Intern), Andersen, N. (Intern)
Pages: 95-99
Publication date: 2004
Main Research Area: Technical/natural sciences
Field-induced magnetic phases in the normal and superconducting states of ErNi$_2$B$_2$C

We present a comprehensive neutron-diffraction study of the magnetic structures of ErNi$_2$B$_2$C in the presence of a magnetic field applied along [010], [110], or [001]. In zero field, the antiferromagnetic structure is transversely polarized with $Q \approx 0.55a^*$ and the moments along the $b$ direction. At the lowest temperatures, the modulation is close to a square wave, and transitions of $Q$ between different commensurable values are observed when varying the field. The commensurable structures are analyzed in terms of a detailed mean-field model. Experimentally, the minority domain shows no hysteresis and stays stable up to a field close to the upper critical field of superconductivity, when the field is applied along [010]. Except for this possible effect, the influences of the superconducting electrons on the magnetic structures are not directly visible. Another peculiarity is that $Q$ rotates by a small, but clearly detectable, angle of about 0.5 degrees away from the [100] and the field direction, when the field is applied along [110] and is approximately equal to or larger than the upper critical field.
Magnetic phase diagram of ErNi$_2$B$_2$C

The magnetic phase diagram of the superconductor ErNi$_2$B$_2$C ($T_c = 11$ K and $T_N = 6$ K) has been studied by neutron diffraction as a function of temperature and magnetic field applied along the symmetry directions [010], [110] and [001] of the tetragonal crystal structure. A series of commensurate magnetic structures, consistent with a transversely polarized spin-density wave with modulation vectors $Q = n/a^*$ ($0.55 \leq n/m < 0.60$) and the spins along $b^*$, have been observed. The experimental data are compared with the results of a mean-field model that has been established from an analysis of bulk magnetization and zero-field neutron diffraction data. The model accounts for most of the observed features but fails to explain the occurrence of a small component $Q_{\delta}$ approximate to $-0.005b^*$ observed close to $H_{c2}$ when the field is applied along $[110]$. (C) 2004 Elsevier B.V. All rights reserved.
Neutron diffraction and theoretical model studies of the field induced magnetic phases of the \(\text{ErNi}_2\text{B}_2\text{C}\) superconductor
We present a (B,T)-phase diagram of the magnetic superconductor TmNi$_2$B$_2$C obtained by neutron scattering. The measurements were performed in magnetic fields up to 6 T applied along the crystalline a axis. The observed phases are characterized by three ordering vectors, $Q(F) = (0.094, 0.094, 0)$, $Q(\text{AI}) = (0.483, 0, 0)$, and $Q(\text{AII}) = (0.496, 0, 0)$, all with the magnetic moment along the c axis. In zero and low fields the Tm 4f-moments order in a long wavelength transverse spin density wave with $Q = Q(F)$. The magnetic $Q(\text{AI})$ structure is stabilized by an applied field of 1 T and a transition to $Q(\text{AII})$ is observed at 4 T. For both transitions there is a broad temperature and field range of overlap between the different states. Surprisingly, we observe that the $Q(\text{A})$ phases persist to increasingly higher temperatures when the field is increased.

Doping with Yb has been introduced to partly suppress superconductivity. In (Tm$_{0.90}$Yb$_{0.10}$)Ni$_2$B$_2$C the $Q(F)\rightarrow Q(\text{AI})$ phase transition is also observed but at a larger transition field compared to the undoped compound. In (Tm$_{0.85}$Yb$_{0.15}$)Ni$_2$B$_2$C the $Q(F)$ phase persists up to at least 1.8 T. The magnetic correlation length of the $Q(\text{AI})$ phase in TmNi$_2$B$_2$C measured parallel and perpendicular to the magnetic field, is constant within 10% at all fields and temperatures.
Superconducting properties of Zn and Al double-doped Mg$_{1-x}$(Zn$_{0.5}$Al$_{0.5}$)$_x$B$_2$

A series of polycrystalline samples of Mg$_{1-x}$(Zn$_{0.5}$Al$_{0.5}$)$_x$B$_2$ (0 less than or equal to x less than or equal to 0.8) were prepared by solid state reaction method and their structure, superconducting transition temperature (T-c) and transport properties were investigated by means of X-ray diffraction (XRD), ac susceptibility, magnetization and resistivity. The double doping leads to decreases in both the lattice parameters a and c, and the T-c decreases with increasing dopant content. A systematical comparison with Al doped- and Li, Al double doped MgB$_2$ of structure, superconducting transition and critical current density (J(c)) is made. It is suggested that the chemical pressure effect plays a more important role influencing the normal state transport and T-c than the change of carrier concentration, and the introduction of disorder into the Mg layers shows little influence improving the irreversibility field and J(c). (C) 2004 Elsevier B.V. All rights reserved.
Influence of magnetism on flux line lattice in TmNi$_2$B$_2$C superconductor

**General information**

**State:** Published  
**Organisations:** Risø National Laboratory for Sustainable Energy  
**Authors:** Abrahamsen, A. (Intern), Eskildsen, M. (Intern), Andersen, N. (Intern), Canfield, P. (Ekstern)  
**Pages:** 20-21  
**Publication date:** 2003  

**Host publication information**

**Title of host publication:** Superconductivity and magnetism: Materials properties and developments. Extended abstracts  
**Place of publication:** Roskilde  
**Publisher:** Risø National Laboratory  
**Editors:** Andersen, N., Bay, N., Grivel, J., Hedegård, P., McMorrow, D., Mørup, S., Kuhn, L., Larsen, A., Lebech, B., Lefmann, K., Lindelof, P., Linderoth, S., Pedersen, N.  
**ISBN (Print):** 87-550-3244-3  
**Main Research Area:** Technical/natural sciences  
**Conference:** 24th Risø International Symposium on Materials Science, Risø, Denmark, 10/09/2003 - 10/09/2003  
**Links:**  
**Source:** orbit  
**Source-ID:** 305808  
**Publication:** Research › Conference abstract in proceedings – Annual report year: 2003

Possible magnetism in vortex cores of superconducting TmNi$_2$B$_2$C studied by small angle neutron scattering

**General information**

**State:** Published  
**Organisations:** Nano-Microstructures in Materials, Materials Research Division, Risø National Laboratory for Sustainable Energy  
**Authors:** Abrahamsen, A. B. (Intern)  
**Number of pages:** 118  
**Publication date:** 2003  

**Publication information**

**Place of publication:** Roskilde  
**Publisher:** Risø National Laboratory  
**ISBN (Print):** 87–550–3265–6  
**Original language:** English  
**Series:** Denmark. Forskningscenter Risoe. Risoe-R  
**Number:** 1425(EN)  
**ISSN:** 0106-2840  
**Main Research Area:** Technical/natural sciences  
**Risø-R-1425(EN), Risø-R-1425**  
**Electronic versions:**  
ris-r-1425.pdf  
**Source:** orbit  
**Source-ID:** 312992  
**Publication:** Research › Ph.D. thesis – Annual report year: 2003

Structure and superconductivity of double-doped Mg$_{1-x}$(Al$_{0.5}$Li$_{0.5}$)$_x$B$_2$  

A series of polycrystalline samples of Mg$_{1-x}$(Al$_{0.5}$Li$_{0.5}$)$_x$B$_2$ (0 < $x$ < 0.6) were prepared by a solid state reaction method and their structure, superconducting transition temperature and magneto-transport properties were investigated by means of X-ray diffraction (XRD), ac-susceptibility and resistance in varied magnetic fields. The double doping leads to decreases in both the lattice parameters a and c. The superconducting transition temperature (T-c) decreases with double doping, but the T-c is systematically higher than that of the single Al-
doped samples. It is suggested that the hole band filling has little effect on T-c at high doping level, while the disorder
induced by doping plays an important role in suppressing T-c. A systematic comparison with Al-doped MgB2 of the
structure, superconducting transition and irreversibility field is made. (C) 2003 Elsevier B.V. All rights reserved.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Xu, G. (Ekstern), Grivet, J. (Intern), Abrahamsen, A. (Intern), Chen, X. (Ekstern), Andersen, N. (Intern)
Pages: 8-14
Publication date: 2003
Main Research Area: Technical/natural sciences

Publication information
Journal: Physica C: Superconductivity and its Applications
Volume: 399
Issue number: 1-2
ISSN (Print): 0921-4534
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.858 SJR 0.492 CiteScore 1.28
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.14 SJR 0.467 SNIP 0.822
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.427 SNIP 0.759 CiteScore 0.99
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.501 SNIP 0.781 CiteScore 0.85
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.46 SNIP 0.649 CiteScore 0.79
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.575 SNIP 0.604 CiteScore 0.79
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.694 SNIP 0.606 CiteScore 0.94
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.67 SNIP 0.632
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.422 SNIP 0.561
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.676 SNIP 0.577
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.555 SNIP 0.725
Scopus rating (2006): SJR 0.682 SNIP 0.629
Web of Science (2006): Indexed yes
Scopus rating (2005): SJR 0.822 SNIP 0.664
Web of Science (2005): Indexed yes
Scopus rating (2004): SJR 0.816 SNIP 0.655
Structure and transport properties of double doped Mg$_{1-x}$(Al$_{0.5}$Li$_{0.5}$)$_x$B$_2$ (poster)

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Xu, G. (Ekstern), Grivel, J. (Intern), Abrahamsen, A. (Intern), Andersen, N. (Intern)
Pages: 79-80
Publication date: 2003

Host publication information
Title of host publication: Superconductivity and magnetism: Materials properties and developments. Extended abstracts
Place of publication: Roskilde
Publisher: Risø National Laboratory
ISBN (Print): 87-550-3244-3
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 305818
Publication: Research › Conference abstract in proceedings – Annual report year: 2003

The magnetic state of ErNi$_2$B$_2$C in an in-plane field

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 14-15
Publication date: 2003

Host publication information
Title of host publication: Superconductivity and magnetism: Materials properties and developments. Extended abstracts
Place of publication: Roskilde
Publisher: Risø National Laboratory
ISBN (Print): 87-550-3244-3
Main Research Area: Technical/natural sciences
Links:
Source: orbit
Source-ID: 305818
Publication: Research › Conference abstract in proceedings – Annual report year: 2003
Flux line lattice symmetries in the borocarbide superconductor LuNi$_2$B$_2$C

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Eskildsen, M. (Intern), Abrahamsen, A. (Intern), Gammel, P. (Ekstern), Bishop, D. (Ekstern), Andersen, N. (Intern), Mortensen, K. (Intern), Canfield, P. (Ekstern)
Pages: 903-905
Conference: International symposium on advances in superconductivity and magnetism: materials, mechanisms and devices (ASMM2D-2001), Mangalore (IN), 25-28 Sep, 01/01/2001
Main Research Area: Technical/natural sciences

**Publication information**
Volume: 58
Original language: English
Source: orbit
Source-ID: 304257

Microstructural dynamics of Bi-2223/Ag tapes annealed in 8% O$_2$

The microstructural dynamics of Bi-2223 tapes are investigated in situ during annealing in 8% O-2 by means of 100 keV x-ray diffraction. A green mono- and a green multi-filamentary tape are annealed at 829.5 degreesC. During ramp-up (Ca,Sr)(2)PbO4 decomposes above 750 degreesC, resulting in an incorporation of Pb in Bi-2212. The associated grain growth of Bi-2212 is the main cause of the strain relief and the c-axis grain alignment of the Bi containing phases. Above 825 degreesC the Bi-2212 partly dissociates into (Ca,Sr)(14)Cu24Ox and a liquid phase. The linewidth of Bi-2212 is constant during the transformation to Bi-2223, indicating no strain or finite-size broadening. The most probable transformation mechanism is found to be nucleation and growth with a fast decomposition of the individual Bi-2212 grain, followed by a growth of Bi-2223 from the Bi-2212 melt reacting with (Ca,Sr)(14)Cu24Ox. The multi-filamentary tape transforms faster and exhibits a much better degree of c-axis alignment. Results are compared to similar studies in air.

**Microstructural dynamics of Bi-2223/Ag tapes annealed in 8% O$_2$**

During a final annealing of a fully converted tape no change is found in the average concentration, stoichiometry and grain misalignment. A post-annealing experiment at 650 degreesC on quenched tapes shows a reaction over 3 weeks, whereby randomly oriented 3222 grains are formed and Bi-2223 is depleted of Pb. Simultaneously, the critical current decreases by a factor of 2.

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Andersen, L. (Ekstern), Poulsen, H. (Intern), Abrahamsen, A. (Intern), Jacobsen, B. (Intern), Tschentscher, T. (Ekstern)
Pages: 190-201
Publication date: 2002
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Superconductor Science & Technology
Volume: 15
Issue number: 2
ISSN (Print): 0953-2048
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 1.426 SJR 1.036 CiteScore 2.63
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.07 SJR 0.967 SNIP 1.45
General information

State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Strong interaction between magnetism and superconductivity in ErNi2B2C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Nørgaard Toft, K. (Ekstern), Abrahamsen, A. (Intern), Andersen, N. (Intern), Jensen, J. (Ekstern), Eskildsen, M. (Intern), Canfield, P. (Ekstern), Kausche, S. (Ekstern)
Publication date: 2002

Host publication information
Title of host publication: Programme. Abstracts. List of participants
Place of publication: Copenhagen
Publisher: HCØ Tryk
Main Research Area: Technical/natural sciences
Conference: 2002 Annual meeting of the Danish Physical Society, Nyborg, Denmark, 30/05/2002 - 30/05/2002
Links:
http://www.nbi.dk/dfs/
Source: orbit
Source-ID: 304106
Publication: Research › Conference abstract in proceedings – Annual report year: 2002

Flux line lattice reorientation in the borocarbide superconductors with H||a parallel to a||a
Small angle neutron scattering studies of the flux line lattice in LuNi2B2C and ErNi2B2C induced by a held parallel to the a axis reveal a first order flux Line lattice reorientation transition. Below the transition the Bur line lattice nearest neighbor direction is parallel to the b axis, and above the transition it is parallel to the c axis. This transition cannot be explained using nonlocal corrections to the London model. In addition, the anisotropy of the penetration depth lambda and the coherence length xi change at the transition.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 320-323
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: Physical Review Letters
Volume: 86
Issue number: 2
ISSN (Print): 0031-9007
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 7.58 SJR 3.622 SNIP 2.464
Neutron scattering studies of the flux line lattice and magnetic ordering in TmNi$_2$B$_2$C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 333-340
Publication date: 2001

Host publication information
Title of host publication: Rare earth transition metal borocarbides (nitrides): Superconducting, magnetic and normal state properties. Proceedings
Place of publication: Dordrecht
Publisher: Kluwer Academic Publishers
Editors: Müller, K., Narozhnyi, V.
ISBN (Print): 0-7923-6878-9
Main Research Area: Technical/natural sciences
Workshop: NATO Advanced Research Workshop on Rare Earth Transition Metal Borocarbides (Nitrides), Dresden, Germany, 13/06/2000 - 13/06/2000
Source: orbit
Source-ID: 303528
Publication: Research › Article in proceedings – Annual report year: 2001

Relation between texture and critical current density of textured YBa$_2$Cu$_3$O$_x$ plates

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Larsen, B. (Ekstern), Larsen, J. (Ekstern), Abrahamsen, A. (Intern), Poulsen, H. (Intern), Tschentscher, T. (Ekstern), Christiansen, J. (Ekstern), Andersen, N. (Intern)
Pages: 3513-3516
Publication date: 2001
Main Research Area: Technical/natural sciences

Publication information
Journal: IEEE Transactions on Applied Superconductivity
Volume: 11
ISSN (Print): 1051-8223
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.45 SJR 0.408 SNIP 0.962
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.42 SJR 0.398 SNIP 1.145
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.403 SNIP 1.06 CiteScore 1.27
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.478 SNIP 1.13 CiteScore 0.83
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.443 SNIP 1.156 CiteScore 1.32
Strong interaction between superconductivity and magnetism in ErNi$_2$B$_2$C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Nørgaard Toft, K. (Ekstern), Abrahamsen, A. (Intern), Jensen, A. (Ekstern), Andersen, N. (Intern), Hedegård, P. (Ekstern), Jensen, J. (Ekstern), Eskildsen, M. (Intern), Canfield, P. (Ekstern), Klenke, J. (Ekstern), Smeibidl, P. (Ekstern), Kausche, S. (Ekstern)
Publication date: 2001
Event: Abstract from Swiss-Danish workshop on neutron scattering, Villigen (CH), 16-17 Nov, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 303634
Publication: Research › Conference abstract for conference – Annual report year: 2001

Superconducting bearings for flywheel applications

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. (Intern)
Number of pages: 45
Temperature dependence of hexagonal to square flux line lattice symmetry transition in LuNi$_2$B$_2$C superconductor

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. (Intern), Eskildsen, M. (Intern), Kogan, V. (Ekstern), Canfield, P. (Ekstern), Gammel, P. (Ekstern)
Publication date: 2001

Host publication information
Title of host publication: Programme. Abstracts. List of participants
Place of publication: Copenhagen
Publisher: HCØ Tryk
Main Research Area: Technical/natural sciences
Conference: 2001 Annual Meeting of The Danish Physical Society, Nyborg, Denmark, 31/05/2001 - 31/05/2001
Source: orbit
Source-ID: 302569
Publication: Research › Conference abstract in proceedings – Annual report year: 2001

We have investigated the temperature dependence of the $H$ parallel to $c$ flux line lattice structural phase transition from square to hexagonal symmetry, in the tetragonal superconductor LuNi$_2$B$_2$C ($T_c = 16.6$ K). At temperatures below 10 K the transition onset field, $H_2(T)$, is only weakly temperature dependent. Above 10 K, $H_2(T)$ rises sharply, bending away from the upper critical field. This contradicts theoretical predictions of $H_2(T)$ merging with the upper critical field and suggests that just below the $H_c2(T)$ curve the flux line lattice might be hexagonal.

Temperature dependence of the flux line lattice transition into square symmetry in superconducting LuNi$_2$B$_2$C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Eskildsen, M. (Intern), Abrahamsen, A. (Intern), Kogan, V. (Ekstern), Gammel, P. (Ekstern), Mortensen, K. (Intern), Andersen, N. (Intern), Canfield, P. (Ekstern)
Pages: 5148-5151
Publication date: 2001
Main Research Area: Technical/natural sciences

We have investigated the temperature dependence of the $H$ parallel to $c$ flux line lattice structural phase transition from square to hexagonal symmetry, in the tetragonal superconductor LuNi$_2$B$_2$C ($T_c = 16.6$ K). At temperatures below 10 K the transition onset field, $H_2(T)$, is only weakly temperature dependent. Above 10 K, $H_2(T)$ rises sharply, bending away from the upper critical field. This contradicts theoretical predictions of $H_2(T)$ merging with the upper critical field and suggests that just below the $H_c2(T)$ curve the flux line lattice might be hexagonal.
Critical current in high-\(T_c\) superconducting BiSCCO-tapes in Ag-clad

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Jacobsen, B. (Intern), Larsen, B. (Ekstern), Abrahamsen, A. (Intern), Andersen, N. (Intern), Wang, W. (Ekstern)
Publication date: 2000

**Host publication information**
Title of host publication: Programme. Abstracts. List of participants
Place of publication: København
Publisher: HCØ Tryk
ISBN (Print): 87-7834-385-2
Main Research Area: Technical/natural sciences
Conference: Danish Physical Society Annual Meeting 2000, Nyborg, Denmark, 08/06/2000 - 08/06/2000
Source: orbit
Source-ID: 301250
Publication: Research › Conference abstract in proceedings – Annual report year: 2000

Morphology of flux line lattice in the borocarbide superconductors

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Lopez, D. (Ekstern), Gammel, P. (Ekstern), Eskildsen, M. (Intern), Abrahamsen, A. (Intern), Mortensen, K. (Intern), Canfield, P. (Ekstern)
Publication date: 2000
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 301221
Publication: Research › Conference abstract for conference – Annual report year: 2000

Oxygen-ordering superstructures in \(\text{NdBa}_2\text{Cu}_3\text{O}_{6.5}\) single crystals investigated by hard-X-ray diffraction

Single crystals of \(\text{NdBa}_2\text{Cu}_3\text{O}_{6+x}\) and \(\text{LaBa}_2\text{Cu}_3\text{O}_{6+x}\) at oxygen concentrations \(x\) approximate to 0.4, 0.5, and 0.76 have been investigated by hard-x-ray diffraction. Intricate oxygen superstructures are found in nonsuperconducting \(\text{NdBa}_2\text{Cu}_3\text{O}_{6.5}\) crystals. By numerical calculations we demonstrate that three unique coexisting oxygen configurations are required to obtain the observed diffraction pattern. The oxygen configurations found are unlikely to give rise to hole doping of the CuO2 planes, explaining why a higher oxygen doping is necessary in \(\text{NdBa}_2\text{Cu}_3\text{O}_{6+x}\) than in \(\text{YBa}_2\text{Cu}_3\text{O}_{6+x}\) to make the compound superconducting.

**General information**
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Frello, T. (Intern), Andersen, N. (Intern), Madsen, J. (Ekstern), Abrahamsen, A. (Intern), Zimmermann, M. V. (Ekstern), Niemöller, T. (Ekstern), Schneider, J. (Ekstern), Wolf, T. (Ekstern)
Pages: R9253-R9256
Publication date: 2000
Main Research Area: Technical/natural sciences

**Publication information**
Journal: Physical Review B Condensed Matter
Volume: 61
Issue number: 14
ISSN (Print): 0163-1829
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 3.34 SJR 1.604 SNIP 1.04
Web of Science (2017): Indexed yes
Flux line lattice reorientation in TmNi₂B₂C studied by Bitter decoration

General information

State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Abrahamsen, A. (Intern), Eskildsen, M. (Intern), Andersen, N. (Intern), Gammel, P. (Ekstern), Bishop, D. (Ekstern), Canfield, P. (Ekstern)
Publication date: 1999
Event: Abstract from 1999 APS Centennial meeting, Atlanta, GA, United States.
Main Research Area: Technical/natural sciences
Source: orbit
Flux line lattice symmetries in the borocarbide superconductors

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Publication date: 1999
Event: Abstract from 1. Euroconference on vortex matter in superconductors, Crete (GR), 18-24 Sep, .
Main Research Area: Technical/natural sciences
Source: orbit

In situ study of equilibrium phenomena and kinetics in a BISCCO Ag tape
Structural changes during the annealing of a mono-filament BiSCCO/Ag tape in air are monitored in situ by synchrotron X-ray diffraction. Starting at 750 degrees C, a very slow ramp rate is used, followed by high temperature cycling to study equilibrium phenomena and kinetics. For the first time, the concentration of the partial liquid is directly monitored. A 3321 phase dissolves below 790 degrees C. Between 760 degrees C and 820 degrees C, the 2212 lattice parameters contract, indicating incorporation of ph and/or Ca. At the same time, grain growth takes place, relieving strains. Between 820 degrees C and 840 degrees C (Ca,Sr)(2)PbO4 dissolves incongruously, while the amount of liquid increases. Conversion of 2212 to 2223 takes place at all temperatures above 820 degrees C. Above 833 degrees C, (Ca,Sr)(2)CuO3 appears. Cycling between 845 degrees C and 860 degrees C, where 2212 has almost disappeared-reveals fast, nearly reversible changes, indicative of several eutectics involving the 2212, 2223, (Ca,Sr)(2)CuO3 and liquid phases. By cycling, the incorporated Ca and/or Pb is lost reversibly. Cooling data are consistent with precipitation of 2212 and 2223 by layer-on-layer growth on the existing grains. Some comments on growth models and a comparison to similar annealing experiments with constant operation temperature are given. (C) 1999 Elsevier Science B.V. All rights reserved.

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Poulsen, H. (Intern), Andersen, L. (Ekstern), Frello, T. (Intern), Prantontep, S. (Ekstern), Andersen, N. (Intern), Garbe, S. (Ekstern), Madsen, J. (Ekstern), Abrahamsen, A. (Intern), Bentzon, M. (Ekstern), Zimmermann, M. V. (Ekstern)
Pages: 254-262
Publication date: 1999
Main Research Area: Technical/natural sciences

Publication information
Journal: Physica C: Superconductivity and its Applications
Volume: 315
Issue number: 3-4
ISSN (Print): 0921-4534
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): SNIP 0.858 SJR 0.492 CiteScore 1.28
Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.14 SJR 0.467 SNIP 0.822
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.427 SNIP 0.759 CiteScore 0.99
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.501 SNIP 0.781 CiteScore 0.85
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.46 SNIP 0.649 CiteScore 0.79
Temperature dependence of the flux line lattice hexagonal to square symmetry transition in LuNi₂B₂C: A crossover from London to Ginzburg-Landay behaviour

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Eskildsen, M. (Intern), Gammel, P. (Ekstern), Bishop, D. (Ekstern), Abrahamsen, A. (Intern), Andersen, N. (Intern), Mortensen, K. (Intern), Canfield, P. (Ekstern)
Publication date: 1999
Event: Abstract from 1st Regional Conference on Magnetic and Supercomputing Materials, Tehran, Iran, Islamic Republic of.
Main Research Area: Technical/natural sciences

Temperature dependence of the flux line lattice square to hexagonal symmetry transition in LuNi2B2C: A crossover from London to Ginzburg-Landau behaviour

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Eskildsen, M. (Intern), Abrahamsen, A. (Intern), Andersen, N. (Intern), Mortensen, K. (Intern), Gammel, P. (Ekstern), Bishop, D. (Ekstern), Canfield, P. (Ekstern)
Publication date: 1999

Host publication information
Title of host publication: Programme. Abstracts. List of participants
Place of publication: København
Publisher: HCØ Tryk
ISBN (Print): 87-7834-335-6
Main Research Area: Technical/natural sciences
Conference: 1999 Annual meeting of the Danish Physical Society, Nyborg, Denmark, 03/06/1999 - 03/06/1999
Source: orbit
Source-ID: 300276
Publication: Research › Conference abstract in proceedings – Annual report year: 1999

In-situ synchrotron studies of the annealing behaviour of high Tc BSCCO/Ag-tapes

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Andersen, L. (Ekstern), Frello, T. (Intern), Poulsen, H. (Intern), Andersen, N. (Intern), Abrahamsen, A. (Intern), Madsen, J. (Ekstern), Pratontep, S. (Ekstern), Bentzon, M. (Ekstern), Schmidberger, J. (Ekstern)
Publication date: 1998

Host publication information
Title of host publication: Danish Physical Society annual meeting 1998. Book of abstracts
Place of publication: København
Publisher: HCØ Tryk
ISBN (Print): 87-7834-277-5
Main Research Area: Technical/natural sciences
Conference: 1998 Annual meeting of the Danish Physical Society, Nyborg, Denmark, 03/06/1998 - 03/06/1998
Source: orbit
Source-ID: 298663
Publication: Research › Conference abstract in proceedings – Annual report year: 1998

Intertwined symmetry of the magnetic modulation and the flux-line lattice in the superconducting state of TmNi2B2C

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Pages: 242-245
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: Nature
Volume: 393
ISSN (Print): 0028-0836
Ratings:
BFI (2018): BFI-level 3
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 14.59
Annealing of Ag-clad BiSCCO tapes studied in-situ by high-energy synchrotron x-ray

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Frello, T. (Intern), Poulsen, H. (Intern), Andersen, N. (Intern), Abrahamsen, A. (Intern), Garbe, S. (Ekstern), Bentzon, M. (Ekstern), Zimmerman, M. V. (Ekstern)
Pages: 1363-1366
Publication date: 1997

Host publication information
Title of host publication: Applied superconductivity 1997. Vol. 2
Place of publication: London
In-situ synchrotron x-ray diffraction on BiSCCO-tapes during annealing

General information
State: Published
Organisations: Risø National Laboratory for Sustainable Energy
Authors: Bentzon, M. (Ekstern), Poulsen, H. (Intern), Garbe, S. (Ekstern), Frello, T. (Intern), Andersen, N. (Intern), Abrahamsen, A. (Intern), Zimmermann, M. V. (Ekstern)
Publication date: 1996
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 295280
Publication: Research › Conference abstract for conference – Annual report year: 1996

Projects:

Superconducting thin-film neutron detector
Jonas Bertelsen
Department of Energy Conversion and Storage
Electrofunctional materials
Department of Wind Energy
Wind Turbine Structures and Component Design
Imaging and Structural Analysis
Period: 02/01/2018 → 20/06/2018
Number of participants: 4
Neutron detector, Superconducting thin film, Coated conductor, Thermal properties
Project participant:
Wulff, Anders Christian (Intern)
Bertelsen, Jonas Lundholm (Ekstern)
Abrahamsen, Asger Bech (Intern)
Kuhn, Luise Theil (Intern)
Project

Vind i ROSKilde
Vind i ROSKilde (VIROS) projektet vil undersøge om man kan benytte en vindkraftstrategi, som er baseret på mellemstørrelses møller under 100 m totalhøjde og som dermed kan opstilles i mange flere områder end 125-150 m møller tidligere undersøgt for Roskilde kommune. Samtidigt undersøges det, om vindmøllerne via placering og udføring kan bruges som en “grøn” kunst installation på lige fod med forbrændingsanlægget for derved at signalere Roskildes grønne aftryk og udvikling. VIROS kommer med tre forslag til, hvorledes lokalitet vindkraft kan bidrage til energiforsyningen og dermed til reduktionen af CO2-udledningen i Roskilde kommune. 1) Mellemstore møller nær infrastruktur, hvor eksempelvis 10 møller placeres langs kommunens infrastruktur i form af motorvej, jernbane eller industri, 2) Erstatning af gamle møller med mellemstore møller (repowering) og 3) Mellemstore møller placeret i landzoner. Disse forslag er i overensstemmelse med Roskilde kommunes strategiske energiplan for 2015-2020 med overvejelser for vindkraft med borgere i centrum. For at øge medejerskabet af møllerne vil der blive arrangeret en informationsmøde i samarbejde med Roskilde Festival og Musicon, hvor interesserede partnere i kommunen vil blive inviteret. Projektet vil til sidst evaluere om en vindstrategi baseret på møller af mellemstørrelse er en mulighed for Roskilde og skitsere hvordan den i givet fald kan implementeres
Lindebjergskolens CO2 fodastryk

Projektet "Lindebjergskolens CO2 fodastryk" har som formål at skabe et undervisningsmateriale, der kan bruges i folkeskolen til at undervise i hvorfor CO2 er en drivhusgas og om de mulige løsninger på klimaudfordringerne med CO2 fra energiforsyningen.

Materialer sigter på at gøre udfordringen med drivhusgassen CO2 så konkret som mulig ved at udregne CO2 fodastrykket fra Lindebjergskolen ud fra el og naturgas forbruget i 2014. Det undersøges om CO2 fodastrykket på 111 tons CO2 i 2014 er stort eller lille og hvad der kan gøres for at reducere det med enten solcelle eller en husstandsvidnine.

Materialer består af en række slides, et regne ark til udregning af CO2 fodastrykket og en rapport som forklarer indholdet af slides og regneark.

Forfatterne håber at materialer kan give inspiration til elever og lærer på Lindebjergskolen samt andre skoler i Roskilde kommune, som vil prøve at udregne deres CO2 fodastryk. Vi modtager gerne CO2 fodastryk udregninger som kan sammenlignes med Lindebjergskolens.
Wind Turbine Structures and Component Design

Lindebjergskolen

Gundsølillehallen A.m.b.a
Period: 01/10/2016 → 01/08/2017
Number of participants: 3
Acronym: LindebjergCO2
Project participant:
Abrahamsen, Asger Bech (Intern)
Thingstrup, Thomas (Ekstern)
Christensen, Allan (Ekstern)
Documents:
LindebjergCO2fodaftftryk_Abrahamsen_19April2018
Lindebjergskolens_CO2_fodafttryk_ABAbrahamsen25Sep2016_Opatereret_5Marts2018
LindebjergskolensCO2Fodafttryk_Energi_FbrugSolVind&Varme_8Aug2016
EnergiFraVindMelleVedLindebjergskolen_SWP25kW_6Marts2018
Invitation LegDigKlog 18.4. 2018

Direct drive High Temperature Superconducting generators for wind turbine

Department of Electrical Engineering
Period: 01/11/2013 → 14/06/2017
Number of participants: 7
Phd Student:
Song, Xiaowei (Andy) (Intern)
Supervisor:
Holbell, Joachim (Intern)
Jensen, Bogi Bech (Intern)
Main Supervisor:
Mijatovic, Nenad (Intern)
Examiner:
Abrahamsen, Asger Bech (Intern)
Qu, Ronghai (Ekstern)
Vanderbemden, Philippe (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Mixed Rare Earth-Fe-B sintered magnets

Department of Energy Conversion and Storage
Period: 15/06/2013 → 06/04/2017
Number of participants: 7
Phd Student:
Xia, Manlong (Intern)
Supervisor:
Abrahamsen, Asger Bech (Intern)
Pryds, Nini (Intern)
Main Supervisor:
Bahl, Christian (Intern)
Examiner:
Grivel, Jean-Claude (Intern)
Christensen, Mogens (Ekstern)
Paturi, Petriina (Ekstern)

Financing sources
Innovative wind conversion systems (10-20MW) for offshore applications

This is the largest ongoing wind energy research project in Europe with 27 participating organizations and coordinated by DTU Wind Energy.

The objectives of the Innwind.EU project are high performance innovative design of beyond-state-of-the-art 10-20MW offshore wind turbines and hardware demonstrators of its critical components.

Department of Wind Energy

Wind Turbines

Wind Energy Systems

Aeroelastic Design

Fluid Mechanics

Period: 01/11/2012 → 31/10/2017
Number of participants: 9

Innovative offshore wind turbines

Acronym: INNWIND.EU

Project participant:

Natarajan, Anand (Intern)
Jensen, Peter Hjuler (Intern)
Buhl, Thomas (Intern)
Abrahamsen, Asger Bech (Intern)
Aagaard Madsen, Helge (Intern)
Hanis, Tomas (Intern)
Stolpe, Mathias (Intern)
Sørensen, Jens Nørkær (Intern)
Barlas, Athanasios (Intern)

Relations

Publications:
Comparison of 10 MW superconducting generator topologies for direct-drive wind turbines
Effects of an electromagnetic shield and armature teeth on the short-circuit performance of a direct drive superconducting generator for 10 MW wind turbines

Modelling environmentally friendly materials for magnetic refrigeration

Department of Energy Conversion and Storage

Period: 01/10/2011 → 17/12/2014
Number of participants: 7

PhD Student:

von Moos, Lars (Intern)

Supervisor:

Engelbrecht, Kurt (Intern)
Nielsen, Kaspar Kirstein (Intern)

Main Supervisor:

Bahl, Christian (Intern)

Examiner:

Abrahamsen, Asger Bech (Intern)
Burriel, Ramón (Ekstern)
Cohen, Lesley (Ekstern)

Financing sources

Source: Internal funding (public)
Name of research programme: Institut, samfinansiering
Project: PhD
Investigating the Feasibility of Direct Drive Wind Turbine Generator Topologies that are Independent of Rare Earth Elements

Department of Electrical Engineering
Period: 15/09/2011 → 09/11/2015
Number of participants: 6
Phd Student:
Henriksen, Matthew Lee (Intern)
Supervisor:
Jensen, Bogi Bech (Intern)
Main Supervisor:
Holbøll, Joachim (Intern)
Examiner:
Abrahamsen, Asger Bech (Intern)
Rasmussen, Peter Omand (Ekstern)
Zhu, Zi-Qiang (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Design af bæredygtige energisystemer i Grønland

Department of Wind Energy
Period: 01/04/2010 → 28/04/2016
Number of participants: 6
Phd Student:
Jakobsen, Kasper Rønnow (Intern)
Supervisor:
Vincent, Claire Louise (Intern)
Main Supervisor:
Hansen, Martin Otto Laver (Intern)
Examiner:
Abrahamsen, Asger Bech (Intern)
Ivanell, Stefan S. A. (Ekstern)
Walløe Hansen, Aksel (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.

Relations
Publications:
Renewable Energy Potential of Greenland with emphasis on wind resource assessment
Project: PhD

Manufacture of 2nd generation high-temperature superconducting tapes with a green processing technology

Risø National Laboratory for Sustainable Energy
Period: 01/09/2008 → 30/11/2011
Number of participants: 7
Phd Student:
He, Dong (Intern)
Supervisor:
Abrahamsen, Asger Bech (Intern)
Andersen, Niels Hessel (Intern)
Main Supervisor:
Grivel, Jean-Claude (Intern)
Examiner:
Jacobsen, Claus Schelde (Intern)
Han, Zhenghe (Ekstern)
Rubesova, Katerina (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Funktionelle superledende og magnetiske materialer til energianvendelser
Department of Physics
Period: 01/07/2008 → 29/03/2012
Number of participants: 6
Phd Student:
Toft-Petersen, Rasmus (Intern)
Supervisor:
Abrahamsen, Asger Bech (Intern)
Main Supervisor:
Andersen, Niels Hessel (Intern)
Examiner:
Jacobsen, Claus Schelde (Intern)
Eskildsen, Morten Ring (Intern)
McEwen, Keith Alistair (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut/centerfinansieret
Project: PhD

Superconducting Wind Turbine Generators
Department of Electrical Engineering
Period: 01/05/2008 → 21/08/2012
Number of participants: 7
Phd Student:
Mijatovic, Nenad (Intern)
Supervisor:
Abrahamsen, Asger Bech (Intern)
Træholt, Chresten (Intern)
Main Supervisor:
Jensen, Bogi Bech (Intern)
Examiner:
Nielsen, Arne Hejde (Intern)
Masson, Philippe J. (Ekstern)
Polinder, Henk (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Globaliseringsmidler
Project: PhD

Magnetfeltsegenskaber af superledere
Department of Physics
Period: 01/02/1999 → 20/05/2003
Number of participants: 7
Phd Student:
Abrahamsen, Asger Bech (Intern)
Supervisor:
Andersen, Niels Hessel (Intern)
Hansen, Jørn Otto Bindslev (Ekstern)
Main Supervisor:
Jacobsen, Claus Schelde (Intern)
Examiner:
Mygind, Jesper (Intern)
Hedegård, Per (Ekstern)
Mesot, Joël (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskerakademiets Samfinansier
Project: PhD

Activities:

12th World Congress of Structural and Multidisciplinary Optimization
Period: 7 Jun 2017
Asger Bech Abrahamsen (Participant)
Mathias Stolpe (Participant)
Department of Wind Energy

Description
Optimal design of a galvanic corrosion protection systems for offshore wind turbine support structures
Degree of recognition: International
Links:
http://www.wcsmo12.org/

Related event

12th World Congress of Structural and Multidisciplinary Optimization
05/06/2017 → 09/06/2017
Braunschweig, Germany
Activity: Attending an event › Participating in or organising a conference

Wind Energy Denmark
Period: 26 Oct 2016
Asger Bech Abrahamsen (Organizer)
Department of Wind Energy

Description
Battle of teh wind generators Workshop at Wind Energy Denmark 2016, Odense 26-27 October (2016) Conference day: Day 1 - Wednesday Date: 26 October, 2016 Time: 14.00 - 15.15 CET Keywords: Superconductor wind turbine generators, direct drive generators, medium speed drive trains Description: What are the options for the future generators of the wind industry? Will copper and silicon steel do? Should we use more advanced materials like permanent magnets or even superconductors? In this session, the findings of the INNWIND.EU project on superconducting direct drive and pseudo magnetic direct drive will be presented together with state-of-the-art drivetrain technologies. A workshop debate will highlight the pros and cons with a resulting vote on the future drivetrain mix in 2030. Presentations: Asger B. Abrahamsen, Senior Research Scientist, DTU Wind Energy: New direct drive technologies of the INNWIND.EU project: Superconducting vs pseudo direct drive (PDF) Jesper Hansen, Coordinator of EcoSwing consortium, Envision Energy (Denmark): Superconducting direct drive development of the EcoSwing project (PDF) Hans-Joergen Thougaard, Magnet Specialist, Siemens Wind Power (Denmark): Characterization of hard magnetic materials in direct drive wind turbines (No presentation available) Anders Bach Andersen, Senior Product Manager, MHI Vestas Offshore: Selecting the optimum solution for drivetrains, seen from a wind turbine owner's perspective (PDF) Moderator: Asger Bech Abrahamsen, Senior Research Scientist, DTU Wind Energy

Battle of the wind generators
Workshop as part of Wind Energy Denmark 2016, Odense 26-27 October (2016)
Documents:
Battle of the drive trains @ WindEnergyDenmark2016
Links:

Related event

Wind Energy Denmark
26/10/2016 → 27/10/2016
Odense, Denmark
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Workshop: Current and future generator-converter systems
Period: 13 May 2011
Asger Bech Abrahamsen (Organizer)
Risø National Laboratory for Sustainable Energy
Materials Research Division
Nano-Microstructures in Materials
Documents:
Workshop programme.pdf

Related event

Workshop: Current and future generator-converter systems
13/05/2011 → 13/05/2011
International Workshop Day at the International conference: E/E Systems for Wind Turbines, Bremen (DE)
Activity: Attending an event › Participating in or organising workshops, courses, seminars etc.

Superconductor based fusion energy
Period: 15 Nov 2010 → 16 Nov 2010
Asger Bech Abrahamsen (Speaker)
Risø National Laboratory for Sustainable Energy
Materials Research Division
Nano-Microstructures in Materials
Description
Place: Lærerkursus Fusionsklassen, Mærsk Mc-Kinney Møller Videncenter, Sorø (DK), 15-16 Nov
Documents:
Superconductor_based_fusion_energy.pdf

Related external organisation

Unknown external organisation
Activity: Talks and presentations › Conference presentations

Feasibility of 5MW superconducting wind turbine generator
Period: 1 Nov 2010 → 3 Nov 2010
Asger Bech Abrahamsen (Speaker)
Risø National Laboratory for Sustainable Energy
Materials Research Division
Nano-Microstructures in Materials
Description
Place: 23rd International Symposium on Superconductivity 2010, Tsukuba (JP), 1-3 Nov

Related external organisation
**Superconducting wind turbines**

Period: 11 Mar 2010  
Asger Bech Abrahamsen (Speaker)  
Risø National Laboratory for Sustainable Energy  
Materials Research Division  
Nano-Microstructures in Materials  

**Description**  
Place: Dutch Power Innovation Day, Twente (NL), 11 Mar

**Related external organisation**  
Unknown external organisation

**Superconducting generators for wind turbines**

Period: 13 Sep 2009 – 17 Sep 2009  
Asger Bech Abrahamsen (Speaker)  
Risø National Laboratory for Sustainable Energy  
Materials Research Division  
Nano-Microstructures in Materials  

**Description**  
Place: 9th European Conference on Applied Superconductivity, Dresden (DE), 13-17 Sep

**Related external organisation**  
Unknown external organisation

**Cutting-edge clean-tech and energy technologies in Denmark: Superledning**

Period: 1 Sep 2008 – …  
Asger Bech Abrahamsen (Speaker)  
Risø National Laboratory for Sustainable Energy  
Materials Research Division  
Nano-Microstructures in Materials  

**Description**  
Place: Copenmind, Copenhagen (DK)

**Related external organisation**  
Unknown external organisation

**Press clippings:**

**The Troubled Quest for the Superconducting Wind Turbine**

Asger Bech Abrahamsen  
26/07/2018  

**Description**  
Article in IEEE Spectrum on Superconducting wind turbine generator and their performance compared to Magnetic Pseudo Direct Drive generator for offshore wind turbine up to 20 MW
The Troubled Quest for the Superconducting Wind Turbine
26/07/2018
IEEE Spectrum (International), New York, United States, Print
Samuel K. Moore
8 sider
Asger Bech Abrahamsen
Press / Media

Drømmen får vinger
Asger Bech Abrahamsen
14/11/2017

Forskere foreslår plads til vindmøler i Roskilde
Asger Bech Abrahamsen
27/05/2017

Skype dialog på web-tv – Grøn omstilling: Panel diskussion af den grønne omstilling med spørgsmål fra gymnasie elever
Asger Bech Abrahamsen
07/11/2016
Skype dialog på web-tv – Grøn omstilling: Panel diskussion af den grønne omstilling med spørgsmål fra gymnasieløver
07/11/2016
Mediehuset København, Web
Sune Gudmundsson
1,5 time
https://mediehuset-kbh.dk/groen-omstilling-svaert-kan-vaere/
Skype dialog on web-tv – Green Energy Transition
Asger Bech Abrahamsen
Department of Wind Energy, Wind Turbine Structures and Component Design

Superconductors to boost wind power
Asger Bech Abrahamsen
20/04/2010
Nano-Microstructures in Materials, Risø National Laboratory for Sustainable Energy, Materials Research Division

Ice-cold physics
Asger Bech Abrahamsen
30/11/2009
Nano-Microstructures in Materials, Risø National Laboratory for Sustainable Energy, Materials Research Division