Superconductivity News Update

Bringing New Power to Electricity

April 2009

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Workshop on Coated Conductors for Applications Discussion Review

OVERVIEW

The ninth International Workshop on Coated Conductors for Applications (CCA2008) was held at the University of Houston in early December 2008. CCA2008 was supported by the Department of Energy, Los Alamos National Laboratory, Oak Ridge National Laboratory, TcSUH, and University of Houston. The goals of the workshop were to establish the basic coated conductor characteristics needed in the production of HTS devices and to identify the most efficient means to achieve these necessary characteristics.

BACKGROUND

There have been great advancements in Research and Development, processing and applications with the 2nd generation (2G) high temperature superconductors, a.k.a. the coated conductor. Developing coated conductors (CCs) will advance electrical power and other large-scale applications. These applications include: transmission cables, fault current limiters (FCLs), motors, generators, transformers, and magnetic systems.

Topics from the Workshop included:

- Substrate materials and buffer layers: architectures, characteristics and processing technologies;
- Long-length, high-speed growth for high-performance, and low-cost/high-yield coated conductors;
- Strategies towards better critical current performance: characterization, microstructure & pinning;
- Coated conductors using non-cuprate materials;
- Coated conductor applications: requirements for power devices, drives, magnets, other;
- Properties of coated conductors beyond pinning: AC losses, electro-mechanical, stability, joints; and Conductor design: coated conductors for HTS power devices, drives, magnets, other.

Presentations from the Workshop are located at the following link:

http://www.tcsuh.uh.edu/cca08/proceedings/presentations/

Short Papers and extended abstracts from the Workshop are located at the following link:

http://www.ewh.ieee.org/tc/csc/europe/newsforum/Contents07.html

Since presentations and papers from the workshop can be viewed on the mentioned websites, the current SNU newsletter will not summarize them. However, since open discussions conducted by participants at the workshop are not reflected in the available materials, the newsletter lists these for your edification. These open discussions contained valuable information concerning the development and application of coated conductors (CCs). They also provide a forum for device manufactures to give their opinions on what issues the wire developers are appropriately addressing and what wire-related issues still need to be addressed.

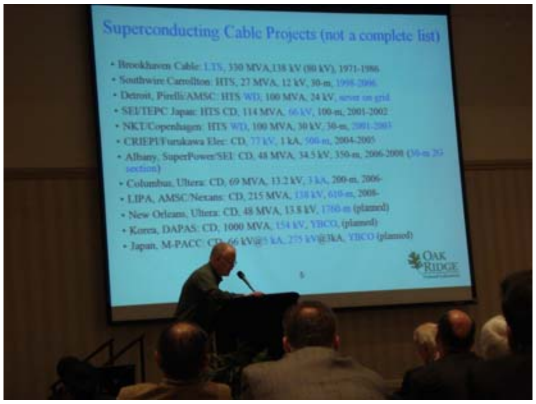
OPEN DISCUSSIONS – Questions, Answers and Comments

The open discussions are assembled by sections from the CCA08 agenda. This will permit you to easily locate more in-depth information on topics that you may find of interest. When available, references to sessions have also been noted.

The open discussion sections contain questions, answers, and comments from workshop attendees to a panel of session speakers. SNU has captured these thoughts to disseminate the significant ideas from the workshop. The Q&As are listed in no particular order and provide insight into updates and achievements on CC related topics.

SNU makes no guarantee on the accuracy of the Q&As, especially when details and numbers are involved. The readers are encouraged to seek further clarifications from experts on items of interest.

1A-13 Open Discussion on HTS Applications Requirements



Mike Gouge led the presentations with his on "HTS Cable Topical Overview."
Hamrick, 2008

Q) What are the YBCO kilometer requirements for applications over the next five years?
A) Transformers would need roughly 18 km per unit, with a few units per year at the outset. HTS high field magnets would need 500 km for an HTS high-field magnet.

Q) What are the metrics for 2G HTS wire? Can it survive in equipment with a 30-year lifetime? What $ per MW delivered do we need to compete with 1G and copper?
A) While 2G wire cost has dropped significantly in recent years, the consensus seemed to be that 2G costs have a long way to go to compete with either. Long-term reliability of 2G wire is an important parameter that needs to be addressed; prototype testing and equipment demonstration projects will provide insights.

Q) What level of AC loss reduction was needed for cables?
A) The conclusion was that there are trade-offs and that the total cost of the cable including cost of losses had to be reduced by half to be competitive with conventional cables.

Q) Is the lack of standard tests for HTS equipment limiting deployment?
A) For the short term, existing standards could be modified. DOE, CIGRE, and EPRI are working on appropriate standards for HTS equipment.

Q) How can HTS facilitate the introduction of DC systems such as cables?
A) EPRI is working on this. The Supergrid project was mentioned. A DC transmission link could extend all the way across the country because there is no changing current such as is required for AC.

Q) What are the AC loss requirements for 2G HTS motor armatures?
A) For 250-Hz systems, an order of magnitude more loss reduction is needed.

2B-10 Open Discussion on Challenges in Long Length Scale Up of High-Performance Coated Conductors

Due to time constraints, comments were brief for this section. The comments made by attendees focused on the need for affordable 2G wire. They also requested the need for length. It was stated that, "wire needs to be at cost with industry, if you get the price lower, industry will buy."

2C-14 Open Discussion on Strategies Towards Low-Cost Coated Conductors

Q) Cost of Capital equipment: Can you compare to the other like industries? What superconductor production lessons have you learned from other similar technologies?

A)

- CC needs to be manufactured at a capacity to meet industry's demand to be viable.
- It is hard to compare to other like industries because of costs
- The manufacturing process needs to be enhanced to improve rates

Q) If you improve precursor/target to film conversion efficiencies during wire production, are there any efficiency losses in the wire? (open session, ref. 2C-12)
A) Higher-rates create no losses.

Q) What is the production rate difference between the Pulsed-laser deposition (PLD) method to in-side-plume deposition (IP-PLD) technique? Does it affect the quality of the coating. (ref. 2C-08)
A) IP-PLD technique increases the production rate by three times. The coating is not affected.

Comments made during this discussion included:

The idea that to reduce the cost of capital equipment, why not ask the government to purchase it and then allow the companies to use it?

Consider alternative techniques to go to large volume. High volume requires new prices and wider strips. Widen the strips to get the product to lower costs to penetrate the market.

2G inherently has lower costs than 1G. Nervous about 2G, "we've got to be able to get to a production stage where people can make the wire. Get the yield up."

2D-18 Discussion on Enhanced Coated Conductor Performance: Characterization

Q) Concerning the flux pinning in YBaCuO films, if you do longer lengths, what are the weaknesses? Are there technical difficulties in developing longer lengths? (ref. 2D-05)
A) It was stated that there were no negative effects in developing longer lengths. The models do not indicate any problems.

3F-14 Discussion on Coated Conductor Properties Beyond Critical Current

Q) How does filamentation influence 2G HTS wire? Why is there coupling in spite of insulation?
A) It was clarified that coupling only occurred when the conductive stabilizer layer is not striated. It was said to be minor compared to the magnetic loses (ref. 3F-08).

Q) Is the AC loss in coils that are striated the same for other applications?
A) Striation into Multi-filamentary structures effectively decreases AC loss in a coil. However, for transformers much longer multi-filamentary CCs are necessary. (ref. 3F-09)

Q) What is the significance of stacking tape?
A) As the number of layers increases, the external field is shielded more effectively decreasing the AC loss. (ref. 3F-02)

Comments from the session included the idea that there is a need to do more prototyping and fabrications to determine the AC loss in CCs. More effort needs to be made in developing newer approaches to progress the technology.

ROUNDTABLE DISCUSSIONS

The Roundtable Discussion from Session H consists of four topic areas where CC innovative ideas, requirements, or achievements were communicated by workshop attendees. References to open and round table discussions have also been provided, where available, for easy location of topic of interest.

3H-01 Technical Roundtable Discussion: Long Length Scale up of High Performance CCs

During the technical roundtable discussion on long length scale-up of high performance CC, it was determined that there is no basic barrier of technology when developing longer length CC. However, there are issues that need to be addressed to achieve long length scale up; for example, there needs to be more uniformity and reduced complexity. Localized critical current drop outs need to be reduced. There needs to be characterization tools to identify drop outs, and root cause analysis is necessary to improve this process. Defect-free production is also necessary. There needs to be a reduction in the number of processing steps, an increase yield per step > 98%, and processes with larger tolerance ranges. Continuous bottleneck steps reduction is also required. Also, engineering issues need to be addressed. This includes the need for process monitoring and in-situ analysis tools, while web handling (tension, weight) gets more difficult and has to be controlled. It was also suggested that CC is not ready for scale up of low AC loss conductors and there needs to be a technology breakthrough. Lastly, a reduction of maintenance and down time in longer length CC processing is necessary for scale-up of CC.

3H-02 Technical Roundtable Discussion: Strategies Towards Low-Cost CC

During the technical roundtable discussion, these points of interest were brought up from the lectures given by presenters. These included the ideas that:

Current price requires very high sales volume to reach $ 50/kA-m. In order to meet expected market requirements, a wire of 750 A/cm is considered as a basis to reach a price of $50/kA-m. (ref. 2C-12) Strategies are needed to reach a 2G HTS wire price of $50/kA-m without High Volume production where it was shown that 300 A/4 mm (750) A/cm is needed to reach the goal.

It is necessary to simplify the buffer architectures to reduce the manufacturing cost of wires such as IBAD-YSZ, IBAD-GSZ, IBAD-MgO, and RABiTS. Benefits of buffer simplification are higher throughput, and lower-cost fabrication while maintaining high performance. Simplified buffer architecture may also reduce the wire complexity that can result in higher yield, and therefore lower wire cost. New, cost-efficient, CC architectures with a reduced quantity of layers are suggested and investigated. (ref. 2C-03) Oak Ridge: Development of Simplified RABiTS and IBAD architecture for Coated Conductors Simplified LMO technology was developed for IBAD-MgO templates.

Chemical homogenization and intermediate stress relief improve strongly with cube feature in RABiTS (ref. 2C-4)

The pulsed-laser deposition (PLD) method fabricates long-length CC with high quality. IBAD-MgO/PLD method produces lower costs due to a fast production rate and the reduction of layers to four. Cost Analysis for Low Cost CC IBAD-MgO provided is 2-3 Yen/A-m=$20-30/kA-m. For commercialization of CC, production costs must be reduced by speeding up the deposition process while significantly simplifying the CC architecture. (ref. 2C-10)

Cost reductions in Trifluoroacetates Metal Organic-Deposition (TFA-MOD) is achieved through increased production rate and higher critical current under supplied magnetic fields. A higher critical current value of 760 A/cm-width under self-fields and the isotropic critical current of 115 A/cm-width under the applied magnetic field of IT were realized by a Y(Gd)BCO film with spreading of BZO nano-particles. This created excellent performance in the field and smooth angular dependence. (ref. 2C-06)

MOCVD technology for YBCO layer/buffer layer fabrication for CC is one of the lowest possible cost capital and operational cost approaches to coated conductor manufacturing. (ref. 2C-09)

3H-03 Technical Roundtable Discussion: Effective Approaches to Enhance CC Performance

During the technical roundtable discussion, these points of interest were discussed:

A new pinning additive, Rare Earth Tantalate Pyrochlore (RE_3TaO_7), was demonstrated to produce a very fine pinning nanostructure from the phase as well as exemplary flux pinning. The nanoparticle self-assembly is readily tunable, allowing for both strong random and correlated pinning. This is revolutionary because for the last five years little was understood about basic optimum additive or "perfect" pinning microstrucures. (ref. 2D-05)

For applications in the magnetic fields such as electric transformer and superconducting magnetic energy storage (SMES), high critical current density (J_c) properties under the applied magnetic fields are important, not only parallel to the c-axis but to all other directions as well. The J_c properties especially under the applied magnetic fields are greatly affected by enhancement of "flux-pinning" in thick REBCO films. An effective method to increase the flux pinning is to introduce nano-scale non-superconducting phase crystals. Introduction of artificial pinning centers (APC) with a similar size to the superconducting coherence length into the films by the trifluoroacetates metal organic deposition (TFA-MOD) method was more difficult than that by the pulsed laser deposition (PLD), because of the differences in the growth mechanisms. (ref. 2D-07)

In order to enhance the J_c characteristics under the magnetic fields, $Y_{1-x}RE_xBa_2Cu_3O_y$ coated conductors (CCs) with artificial pinning centers were prepared by using the starting solution containing Zr-salt, where RE is Gd or Sm, in the trifluoroacetates -metal organic deposition. From microstructure observation, $BaZrO_3$ (BZO) nanoparticles were uniformly dispersed in these films. High J_c in the magnetic fields and significant enhancement of J_c for all applied magnetic field angles were achieved. (ref. 2D-07)

3H-04 Technical Roundtable Discussion: CC Properties Beyond Critical Current

During the technical roundtable discussion, these points of interest were communicated:

It is extremely important to reduce AC losses in CC for cable and rotating machinery application. AC losses in 2G HTS wire are mainly associated with the hysteretic magnetization of the superconducting layer. To reduce AC losses a technique of striating the YBCO layer into narrow filaments was developed. (ref. 3F-08)

How low should the AC loss in HTS tape be? It depends on the application. In the case of a power transmission cable, it should secure the electromagnetic loss below 1-2 W/m. Optimization of the cable architecture is necessary to utilize the potential of coated conductor and to minimize the AC loss of the cable. (ref. 3F-03)

AC loss in coils: Physical principals are understood but its application to devices is not straightforward; therefore, it is necessary to make experiments on prototypes and test devices. (ref. 3F-01)

Quench and stability: We still do not have good quench detection and protection for the 2G devices. 3D quench model missing. (ref. 3F-01)

CONCLUSION

The CCA08 was attended by approximately 120 attendees including wire manufacturers, industry and academic leaders, and HTS device manufactures. The workshop was highly regarded and generated thought-provoking discussions. During the workshop, CC characteristics were established for the production of HTS devices. HTS device manufacturers directed wire-related issues to wire developers to express their needs. The CCA08 workshop also looked at requirements necessary to fabricate long-length CC, reduce costs, increase production, and establish market viability.

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UPCOMING EVENT—MARK YOUR CALENDARS

2009 DOE Office of Electricity Delivery and Energy Reliability HTS Peer Review,
August 4-6, 2009

Location: Alexandria, VA

For more information, please visit the website: http://www.htspeerreview.com/
Or send questions to: Tenley Dalstrom, tdalstrom@energetics.com

ABOUT THIS UPDATE

The High-Temperature Superconductivity News Update is compiled by Bob Lawrence & Associates Inc. on behalf of the Department of Energy's superconductivity program and is issued periodically as events warrant. Current and past issues are available at http://www.superconductivitynewsupdate.com/.

Please let me know if you would like more information or story ideas on any of these news items involving high-temperature superconductivity---a clean and capable new electricity technology for the 21st century. If you have any other comments or questions, please let me know.

Thank you very much.

Jodi Hamrick

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