Accelerated Coated Conductor Initiative

SUPERCONDUCTIVITY
FOR ELECTRIC SYSTEMS

ACCELERATED COATED CONDUCTOR INITIATIVE

Coated conductors represent one of the most exciting developments in high-temperature superconducting (HTS) technology. The achievement of continuous processing of coated conductors will enable the production of large scale quantities of low cost superconducting wire that can be integrated into the next generation of electric utility power applications. HTS wires have the potential to carry 100 times the current without the resistance losses of comparable diameter copper wire. HTS power equipment has the potential to be half the size of conventional alternatives with the same power rating and has only half the energy losses. The prospective energy and dollar savings are tremendous. Many nations are aware of this possibility, and a worldwide competitive effort has already begun. With support from the U.S. Department of Energy (DOE), Office of Power Technologies (OPT), the Accelerated Coated Conductor Initiative (ACCI) will help the U.S. maintain its leadership status in the development of HTS wires and systems, through shared collaborations between the DOE National Laboratories, universities, and industry partners. The effort will ultimately allow for successful introduction of HTS products into the marketplace.

SUPERCONDUCTIVITY *is defined as the ability of certain materials to conduct electricity without losses due to electrical resistance. In 1986, high temperature superconductivity (HTS) was born with the discovery of certain ceramic oxides capable of achieving superconducting temperatures by cooling with liquid nitrogen. Since then, there has been a worldwide effort directed towards the commercialization of HTS technology and the U.S. holds an important role in this competitive process.*

NEED

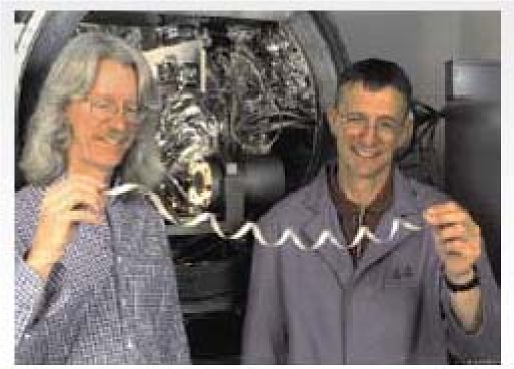
As a result of the growing demand for electricity, the U.S power industry will need to be able to respond to changing transmission patterns by upgrading the infrastructure of its electricity sector. This will result in the replacement of aging equipment that will soon exceed its designed lifespan. Currently, 70% of the U.S. transmission lines and transformers are over 25 years old. By upgrading electric systems with reliable and efficient superconducting equipment, which is characterized by much higher levels of capacity, space and cost savings in electricity transmission and generation will be realized. Almost 7% of the total electricity generated is now lost in transmission and distribution. This translates to billions of dollars that could be saved by taking advantage of the zero resistance capabilities of HTS power equipment. When HTS wire reaches a production level appropriate for its commercialization, it can then be introduced into electric systems thereby increasing reliability and the overall power delivery capacity of the electric grid. However, before HTS applications can further advance in the electricity market, it will be necessary to address several technological barriers that are impeding the attainment of the overall goal of commercializing HTS wires and systems in a timely and cost effective way.

Previous efforts in HTS wire development have been successful in production through a process that involves packaging the superconducting materials in silver tubes, which are rolled, heat-treated and converted into tapes (powder-in-tube method). First generation wires created under this process have also been successfully introduced into prototype electric systems.

VISION:

High-performance Yttrium Barium Copper Oxide (YBCO) coated conductors will be available in 2005 in kilometer lengths. For applications in liquid nitrogen, the wire cost will be less than $50/kA-m, while for applications requiring cooling to temperatures of 20-60 K the cost will be less than $30/kA-m. By 2010 the cost-performance ratio will have improved by at least a factor of four.

COATED CONDUCTORS are created through new approaches, where specially prepared metal strips are coated with HTS thin films. In 1995, DOE's Los Alamos National Laboratory (LANL) announced the improvement of a coated conductor processing technique, Ion Beam-Assisted Deposition (IBAD). The following year Oak Ridge National Laboratory (ORNL) discovered a competing process, Rolling Assisted Biaxial Textured Substrates (RABiTS) and Argonne National Laboratory recently has been developing another technique, Inclined Substrate Deposition (ISD). All coated conductors are often referred to as second generation conductors.



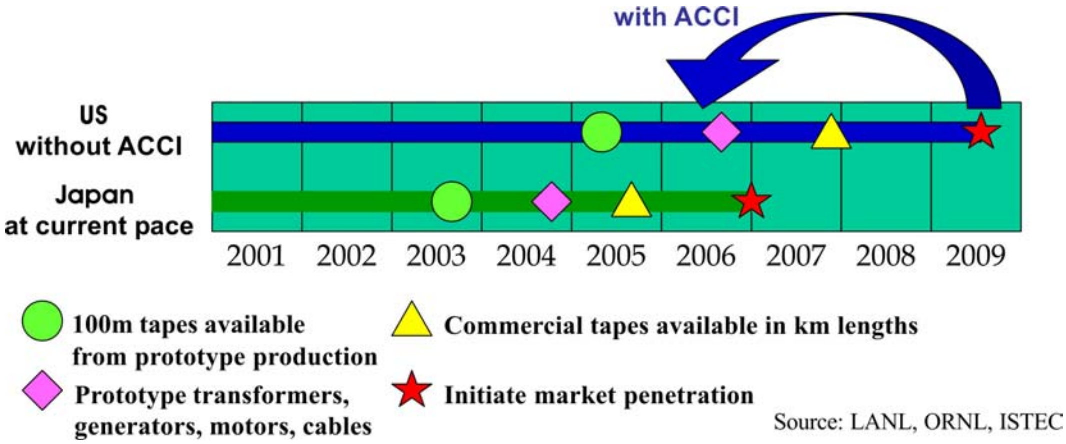
Steve Foltyn and Paul Arendt from LANL holding a coated conductor tape

It has been estimated that approximately 1.5 tons of silver are needed to produce one mile of cable under the powder-in-tube method, but on the other hand, coated conductors only require a small silver overcoat for optimal operation. This advantage greatly reduces the cable per meter production costs under the coated conductor approach. To date, coated conductor cables have been made in short lengths of 1-5 meters and a strong effort is needed to overcome the barriers that limit each of the different production processes.

The DOE Office of Power Technologies created the Accelerated Coated Conductor Initiative (ACCI) ***to scale up coated conductor production and allow for continuous processing of high-quality, low cost coated conductors that will lead to industrial-scale commercial manufacturing***. The program combines the efforts of the national laboratories, university research and industry partners.

The national laboratories developed the scientific process reasoning behind the new technology to reduce risks and costs for the private sector. Los Alamos, Oak Ridge, and Argonne National Laboratories have established Cooperative Research and Development Agreements (CRADAs) with several companies to promote production of coated conductors, namely American Superconductor, 3M, IGC-SuperPower, MicroCoating Technologies, Oxford Superconducting Technology and Neocera. Each individual company selects its desired coated conductor production approach. Various other firms have expressed interest in collaborating with the national laboratories to ultimately transfer coated conductor technology to power applications such as transmission cables, motors, transformers, generators, fault current limiters, and magnetic separators. Additionally, several universities provide the national laboratories with fundamental research necessary to overcome the current production barriers.

Prior to the ACCI, the U.S. was poised to lose the lead in coated conductor development to the highly funded government programs of Japan and Europe.



The ACCI will enable the U.S. to maintain the lead in coated conductor processing and to benefit from replacing existing electric systems with more efficient coated conductor HTS power technology.

User Facilities are Key to Industrial Participation and Technology Transfer

At the new Los Alamos Research Park Building, 10,000 sq ft accommodate four labs that are dedicated to fabrication and evaluation of coated conductors, three other labs for HTS applications, and fourteen offices for staff and visiting collaborators. New equipment for research and development of coated conductors has been designed and most of it has already been delivered and installed. The new equipment includes reel-to-reel systems for electropolishing of metal tapes, an IBAD e-beam chamber and a PLD chamber (powered by a 200-W excimer laser) all for continuous processing of up to 100 m lengths. LANL's strategy consists of integrating a reel-to-reel deposition and monitoring systems to increase the rate of development of coated conductors under their coating process. In addition, Argonne National Laboratory will be working closely with LANL's facilities to scale up production of coated conductors using the ISD process.

New building at the Los Alamos Research Park, finished in April 2001

ORNL created two new laboratories from approximately 2,500 sq ft of underused space. The labs were prepared with all utilities and services needed for buffer layer and superconductor deposition equipment, a reel-to-reel x-ray diffraction unit, and other characterization systems. Key labs include a reel-to-reel processing laboratory (with apparatus for precursor deposition, buffer layer deposition, and a batch conversion furnace system); a tape cleaning station; and a characterization laboratory (reel-to-reel x-ray diffraction, 9-T magnet with insert for J_c measurement system, and reel-to-reel surface roughness measurement, as well as critical current measurement systems). Offices for guest users and ORNL staff are provided.

ORNL's ACCI lab created from 2,500 sq ft of renovated space

The combination of the advanced high-tech production tools, present at the laboratories, with the knowledge and skills of the program participants, will accelerate the development of existing techniques and create alternate production approaches. The facilities allow industries to bring back the techniques developed at the laboratories and integrate them into a manufacturing base. The end result will speed up the introduction of coated conductor HTS technology into the marketplace.

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Coated Conductor Technology Development Roadmap: http://www.eren.doe.gov/superconductivity/pdfs/ccroadmap8_23.pdf
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Cover: From left to right; Metfab industrial equipment for wet electrochemistry, Marshall Reed and Bill Madia at ORNL ribbon cutting, Studying ORNL's equipment – Charles Cook of the House Science Committee, Debbie Haught and Roger Meyer of DOE's Office of Power Technologies, ORNL reel-to-reel J_c apparatus.