HIGH TEMPERATURE SUPERCONDUCTING WIRES
Research & Development

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http://www.csm.ornl.gov/Internships/posters04/n_cunningham_pa.pdf

ABSTRACT

Researchers in the Metals and Ceramics Division (M&C) at the Oak Ridge National Laboratory have found a new way to lay down a proper foundation to form a new high-temperature superconducting (HTS) wire. HTS can carry 710 times more current per unit area than conventional copper wire without energy-wasting resistance due to the unique combination of specifically textured, buffer layers that maintain the texture and deposited film. To develop these HTS wires, researchers in M&C created a Rolling-Assisted Biaxial Textured Substrates (RABiTS) process. The three main steps of the RABiTS process are: biaxially textured metal fabrication, buffer layer deposition, and superconductor deposition. The first step of RABiTS was to produce the foundation prepared from nickel ingots by the using rolling-heating treatment. Next, an E-beam evaporation system was created to produce thin buffer layers of palladium, cerium oxide, and yttria-stabilized zirconia on the foundation. Finally, a pulsed-laser deposition system was created to deposit high-temperature superconductor yttrium-barium-copper-oxide (YBCO) on the conditioned surface to complete the HTS structure. These three steps of RABiTS are the key to the entire HTS structure because nickel and copper atoms tend to trade places, making nickel and YBCO incompatible. The buffer layers provides a chemical barrier between the nickel and the superconductor while maintaining the texture. The major focus of this research is on the ability to characterize HTS wires. To characterize an HTS wire, a researcher must be able to measure the critical current, *Ic*, and transition temperature, *Tc*, of superconducting tapes. The unique design of long-length Ic and Tc systems allows a researcher to make these characterizations. To make the measurements, a silver sputtering machine has been developed that allows users to coat samples of HTS tapes with silver, which allows the Ic and Tc systems to be able to give an electromagnetic property characterization of an specific HTS sample. This ability is important in the development and design process of long-length HTS wires.

What is it?

- ✓ **HTS wire is a phenomenon which combines specific materials that, when cooled to extremely low temperature, produces zero resistance. When current is flowing through the wire, it produces no heat. A superconducting electromagnet can stay energized forever. With that stated, HTS would have many uses in today's world.**

Why?

- ✓ **HTS wires are more efficient**
  - ✓ **produces 100 times more electrical current than copper wires**
- ✓ **Costs less**
  - ✓ **can reduce energy loss by 50 percent**
- ✓ **Safer**
  - ✓ **Eliminates risk of fire and hazardous spills associated with the dielectric oil that powers the copper wires**

RABiTS™

Rolling-heating Treatment

- First step of RABiTS
  - produce the proper foundation prepared from nickel ingots by rolling-heating treatment
  - provides the underlying foundation onto an substrate for the superconducting wire birth process.
  - provides high degree of grain alignment for more current flow
  - provides a chemical barrier between the nickel and the superconductor while maintaining the texture

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E-Beam Evaporation System

- The second step of the RABiTs process is the E-Beam Evaporation that deposit thin buffer layers of palladium, cerium oxide, and yttria-stabilized zirconia on nickel tapes.

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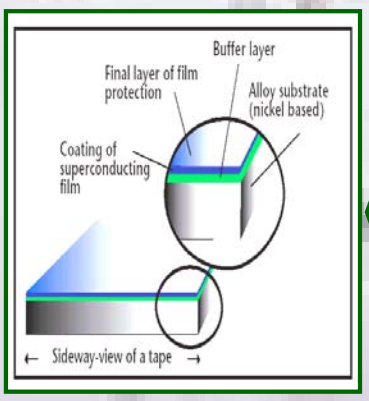

Pulse-laser Deposition System

- Final step of RABiTS process is, the Pulsed-laser Deposition that deposit high-temperature superconductor yttrium-barium-copper- oxide (YBCO) on the conditioned surface of the nickel tape to complete the HTS structure.

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Future of HTS Wires

Interest in HTS wires around the world is rising. The future of superconductors is bright and one of the most talked about aspects in superconductivity. The development of superconductors will allow many improvements using devices as supercomputers, the Superconducting Quantum Interference Device (SQUIDS), electric power motors, and magnetically levitated bullet trains. With increased interest from the government and commerce, researchers are trying to research deeper into superconductors with higher Tc's. There have been few major new discoveries recently, however superconductors are still making major progress. The next step for the future of superconducting research is to find materials that can become superconductors at room temperature. Once researchers have accomplished this goal in superconducting research, the entire world of electronics, power and transportation will be revolutionized.

Characterization

Two of the most important performance parameters for large-scale superconductor applications are the critical current and transition temperatures.

At ORNL, two unique Ic systems and an Tc system were created to give measurements necessary to characterize the performance of superconductors.

These measurements are difficult to measure correctly and accurately; thus, these measurements are often subject to analysis and debate.

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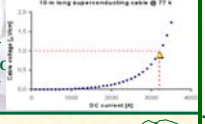
Critical Current Characterization Systems I

- Importance of Critical Current
  - distinguish a good or bad sample
    - Good sample = Mass product
    - Bad sample = Bad HTS sample

- Ic is determined by
  - measuring the voltage (electrical field) versus the DC current for the cable, the IV-curve (R=I/V)



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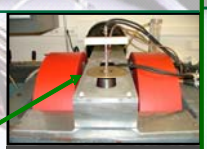
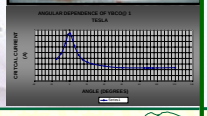
Critical Current Characterization Systems II

- System II
  - measurements
    - more accurate critical current
    - critical current at specified angles chosen by user at particular external magnetic field





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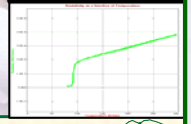
Transition Temperature Characterization System

- Transition Temperature
  - provides temperature at which the superconductor enters the superconducting state
  - When T<Tc
    - superconductor drops sharply to zero
    - resulting in virtually lossless flow of current

- Measurements
  - system at vary temperature reads an voltage at constant current giving an resisitive transition vs. temperature



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