Compact high-temperature superconducting cables demonstrated at NIST

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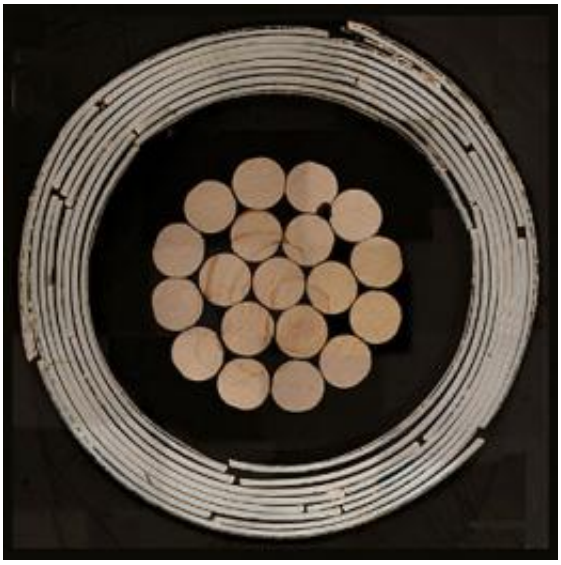

Cross-section of a high-temperature superconducting cable design invented at NIST. In the center are copper wires bundled with nylon and plastic insulation. The outer rings are a series of superconducting tapes wrapped in spirals around the copper. The cable is 7.5 millimeters in outer diameter. Credit: van der Laan/NIST

A researcher at the National Institute of Standards and Technology has invented a method of making high-temperature superconducting (HTS) cables that are thinner and more flexible than demonstration HTS cables now installed in the electric power grid while carrying the same or more current. The compact cables could be used in the electric grid as well as scientific and medical equipment and may enable HTS power

transmission for military applications.

Described in a paper just published online,* the new method involves winding multiple HTS-coated conductors** around a multi-strand copper “former” or core. The superconducting layers are wound in spirals in alternating directions. One prototype cable is 6.5 millimeters (mm) in outer diameter and carries a current of 1,200 amperes; a second cable is 7.5 mm in diameter and carries a current as high as 2,800 amperes. They are roughly one-tenth the diameter of typical HTS cables used in the power grid. (Standard electrical transmission lines normally operate at currents below 1,000 amperes.)

HTS materials, which conduct electricity without resistance when cooled sufficiently (below 77 K, or minus 196 C/minus 321 F, for the new cables) with liquid nitrogen or helium gas, are used to boost efficiency in some power grids. The main innovation in the compact cables is the tolerance of newer HTS conductors to compressive strain that allows use of the unusually slender copper former, says developer Danko van der Laan, a University of Colorado scientist working at NIST.

“The knowledge I gained while working at NIST on electromechanical properties of high-temperature superconductors was very important for inventing the initial cable concept,” van der Laan says. “For instance, my discovery that the conductor survives large compressive strains made me realize that wrapping the conductor around a small diameter former would most likely work.”

Van der Laan and NIST colleagues demonstrated the feasibility of the new concept by making several cables and testing their performance. They used an HTS material with a critical current that is less sensitive to strain than some other materials. Although the prototype cables are wound by hand, several manufacturers say mass production is feasible.

NIST researchers are now developing prototype compact HTS cables for the military, which requires small size and light weight as well as flexibility to pull transmission lines through conduits with tight bends. Beside power transmission, the flexible cabling concept could be used for superconducting transformers, generators, and magnetic energy storage devices that require high-current windings. The compact cables also could be used in high-field magnets for fusion and for medical applications such as next-generation magnetic resonance imaging and proton cancer treatment systems.

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More information: * D.C. van der Laan, X.F. Lu, and L.F. Goodrich. Compact $GdBa_2Cu_3O_{7-\delta}$. coated conductor cables for electric power transmission and magnet applications. *Superconductor Science & Technology*. 24 042001, doi: 10.1088/0953-2048/24/4/042001

** The superconducting compound used in the work is gadolinium-barium-copper-oxide, or $GdBa_2Cu_3O_{7-\delta}$.

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