Saving the Grid

UT Physicists Help Earn an R&D 100 Award for Superconducting Wires

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In turns out that round over flat works best not only in describing our planet, but also in making wires that carry electric current most efficiently. Professor Jim Thompson and Research Assistant Professor Yuri L. Zuev and their colleagues have fabricated and tested a new kind of superconducting wire that avoids the "frictional" losses that have plagued earlier versions. Their efforts on "Superconducting Wires by Expitaxial Growth on SSIFFS (Structural, Single-Crystal, Faceted, Fibers)" have culminated in an R&D 100 Award in the Electrical Equipment category.


Dr. Jim Thompson

A lot has changed since the ancients discovered they could rub a piece of amber with animal fur and generate static electricity. Banking, science, communications, education, and medicine are now in large part dependent on the delivery of electric power, so much so that demand has increasingly taxed existing electrical grids. Superconductivity, where steady currents can move along seamlessly without resistance, is a natural phenomenon that could help alleviate the problem, but developing wires with this property has brought its own set of challenges.

As Thompson explained, AC (alternating current) is ubiquitous in electrical power. The stronger the current, the stronger the magnetic field that wraps around the wire carrying it, and the associated energy losses are magnified in earlier superconducting tapes. "It's sort of like dragging something back and forth," he said. These wires were based on flat tape geometries and suffered from high hysteretic losses, which means "basically a magnetic friction loss."

The earliest wires were flat in design because of the need for epitaxy in making strong superconductors, Thompson said. Epitaxy is the process of growing a layer of one substance on a single crystal of another, so that the layers have the same crystal structure. If the grains in a high-Tc superconductor are randomly oriented without set, even (low angle) boundaries, the material suffers from weak links and won't conduct current very well. Thompson compares it to rolling a marble along the cracks in a parquet floor. Supercurrents don't like to cross grain boundaries if they don't line up uniformly, he said. "They may do it, but they'll make lots of heat in the process."

Epitaxy coaxes superconducting grains to align themselves to the approximation of a single crystal, thereby avoiding weak links at the boundaries. Flat tape geometry superconductors emerged based on this process, because if you need an atomic template and large current capacity, Thompson said, flat is the best shape to use. But the flat tape design also meant high hysteretic losses. Designing more narrow superconducting wires minimizes those losses. To capitalize on that principle, researchers from UT and Oak Ridge National Laboratory fabricated a round, single-crystal superconducting wire that can operate at 65 to 77 degrees Kelvin and has low AC hysteretic loss—the only one of its kind.

Although Thompson said the wires are slightly "oval in shape," they're still not much wider than they are thick. Made on a sapphire core, which is strong and fairly flexible, the wires can be transposed or twisted into bundles, another advantage over flat tape designs.

"It's easy to make something round," Thompson said. "What's hard is to make something round that conducts high density current. The big picture thing we'd like to do is use this gift from nature—these superconducting materials—for more energy efficient cables, motors (and) smart, resilient electronic components."

If history is any indicator, they may have a very good chance of doing so. Since 1963, the R&D 100 Awards, sponsored by *R&D Magazine*, have identified revolutionary technologies including the ATM, the fax machine, and HDTV. The 47th Annual R&D 100 Awards recognize the 100 most technologically significant products introduced into the marketplace over the past year. Recipients will be honored at an awards banquet in Orlando on November 12. Thompson and Zuev worked on the project with Amit Goyal (principal investigator), Eliot Specht, Claudia Cantoni, and Dominic Lee, all of ORNL; and Sung Hun Wee of the UT Department of Materials Science and Engineering, all with support from the Department of Energy's Office of Electricity Delivery and Energy Reliability.