OAK RIDGE NATIONAL LABORATORY

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News Release

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ORNL uses nanodots to boost superconductivity

OAK RIDGE, Tenn., April 3, 2006 — Oak Ridge National Laboratory researchers have demonstrated a way to sustain high supercurrents in wires in the presence of a large applied magnetic field -- a step which could greatly expand practical applications of superconductors.

By creating columns of self-aligned, non-superconductive "nanodots" within the superconductor, the ORNL team has produced a high-temperature superconductor that works even in a powerful magnetic field.

The ORNL work, reported in the current issue of Science, increases the plausibility of high-temperature superconductors in motors, generators, air defense systems and other applications once limited by the negative effects of applied magnetic fields.

Lead author for the Science paper is Sukill Kang, a post-doctoral fellow in the Materials Sciences and Technology Division at ORNL.

Kang's mentor, Amit Goyal, is an ORNL distinguished scientist and the project's technical leader who also co-developed the rolling-assisted-biaxially-textured substrates (RABiTS) process which deposits brittle, ceramic-like high temperature superconducting materials onto a substrate, or template, that gives the wires the texture, flexibility and mechanical strength of metal.

Superconductors carry large amounts of current when cooled, offering much more efficient energy transmission for a wide range of uses. Advances in achieving supercurrent at higher temperatures with liquid nitrogen, which is more practical than liquid helium needed to cool older superconductors at lower temperatures, have made the technology more applicable.

However, magnetic fields have remained an obstacle to many superconductor applications, Goyal said. The problem is that naturally occurring vortices -- whirling cylindrical forces between the atoms of the superconducting material -- begin to move about under applied magnetic fields, creating electrical resistance and power dissipation. Large scale supercurrents can flow only if these vortices remain firmly locked in place, or "pinned."

ORNL's answer was to incorporate "misfit" nanodots of non-conductive material throughout the entire thickness of the superconductor and effectively pin the vortices and prevent their movement, enabling high supercurrents even in the presence of high applied magnetic fields.

"Most applications of superconductors require the superconductor to be in large applied magnetic fields," Goyal said. "Thus, to truly sustain very high current in strong magnetic fields, you must prevent the vortices from moving.

"One way to do that is to have non-superconducting regions which "pin" or prevent these vortices from moving. They provide a barrier. To get adequate, effective, non-superconducting regions to do this work for us, they had to be of the nanoscale dimensions.

"This is a nice combination of the use of nanotechnology and superconductivity. With continued advances in nanotechnology, maybe even more interesting things are possible in the future.

Bob Hawsey, manager of ORNL's superconductivity program, said the work, sponsored by the Department of Energy's Office of Electricity Delivery and Energy Reliability, may lead to even more developments in superconductivity.

"These results demonstrate the potential for the 'second generation' high-temperature superconductors to have broad applicability in the electric power sector of our economy" Hawsey said. "Our team is working with three U.S. companies to learn how to apply these innovative, short-sample laboratory results to industrial processes."

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