Nano World: Superconducting wires

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Nanotechnology could help enable the next generation of superconducting wires for everything from new city power grids to levitating trains, experts told UPI's Nano World.

Superconductors allow electrical current to flow with virtually no resistance. This enables superconducting wires to carry high levels of current very efficiently. The problem is these wires often stop being superconducting when around strong magnetic fields, the kind often generated by motors and power lines.

Researcher Amit Goyal, a materials scientist at Oak Ridge National Laboratory in Tennessee, and his colleagues experimented on wires made of yttrium-barium-copper-oxygen, or YBCO, which is a high-temperature superconductor. This means it operates at about the same temperature nitrogen is liquid at, relatively high compared the near absolute zero temperatures other materials are superconducting at.

Passing a current through a superconductor while in the presence of large magnetic fields causes magnetic vortexes move, which results in electrical resistance. Goyal and his colleagues discovered that columns of dots only 10 nanometers or so wide made of a non-superconducting ceramic known as barium zirconate could help overcome this interference.

The researchers created their wires by growing films of YBCO on top of flexible metal foundations. Mixed in with the YBCO were barium zirconate nanodots. Due to interactions between the barium zirconate and the superconductor, these nanodots automatically lined up into columns that ran vertically through YBCO.

These columnar defects in the superconductor serve as "a barrier for the magnetic flux to move, and hence allows the superconductor to carry supercurrents in high magnetic fields," Goyal said. The nanometer scale of these dots is crucial for pinning down the magnetic flux -- if they were larger, the vortexes could move around within them, Goyal explained. "It's a considerable advance," said materials scientist David Larbelestier at the University of Wisconsin in Madison.

The results are wires that for the first time meet or exceed the high temperature superconductor industry's performance standards for many large-scale applications, including motors, power cables and high-strength magnets. Goyal expected companies to have superconducting wires possessing such nanoscale defects within "a few years."

"One can think about super-efficient, environmentally friendly motors, and underground transmission lines that can revolutionize the power grid," Goyal said. "In congested cities like New York, the power requirements are increasing daily, and in time, it will reach capacity and the grid will not be able to transfer any more power. Replacing them with superconducting wires is perhaps the only way to move forward."

While the researchers have demonstrated their findings in short wires just slightly more than a half-inch long, Goyal noted a lot more work remained open when it came to creating mile-long wires power companies would likely need.

Goyal and his colleagues present their findings in the March 31 issue of the journal Science.