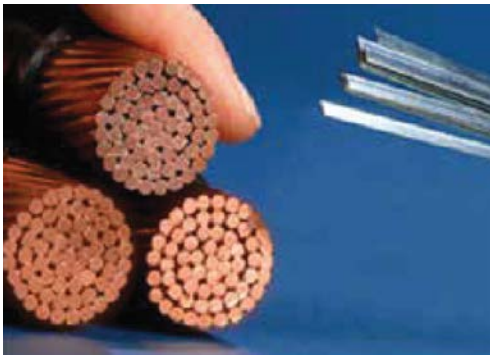

ABOUT THE IMAGES

Superconducting devices known as SQUIDs enable mapping of neuron activity in the human brain.
(GOA NOVI / SHUTTERSTOCK.COM)

Superconducting microwave filters in cell phone towers enable high speed transmission of many signals without interference.
(VLAD TEODOR / SHUTTERSTOCK.COM)

Compact high-temperature superconducting cables (right) replace much larger conventional copper cables (left).
(COURTESY AMERICAN SUPERCONDUCTOR CORP.)

MAKING SUPERCONDUCTIVITY USEFUL

The ability of certain materials to carry an electric current without any resistance, heating, or power loss remains a mysterious—if very useful—phenomenon. An initial breakthrough 60 years ago in metal alloys cooled to the temperature of liquid helium enabled the creation of powerful magnets and the MRI machines used for medical imaging. The more recent discovery of superconductivity at higher temperatures in ceramic materials has opened up a wider array of applications, thanks to several decades of research supported by the Basic Energy Sciences (BES) office of DOE and subsequent applied research by other DOE offices and by industry.

The Breakthrough

Understanding and fine-tuning material properties to enable more practical applications.

- Using BES shared research facilities to probe the magnetic structure of high-temperature superconducting materials with neutron beams and to study their electronic structure with x-ray or ultraviolet beams provided insights that enabled scientists to adjust compositions to allow superconductivity at higher temperatures.
- Using BES facilities to show that exposing superconducting materials to radiation could double their current-carrying capability.

The Impact

Commercial superconducting cables for many uses and superconducting devices that can be readily cooled with small refrigeration systems, enabling widespread deployment.

- Protecting the nation's electrical grid by using superconducting cables that can carry very high currents as fail-safe devices. One early deployment in Chicago supported by the Department of Homeland Security connects many substations, increasing capacity, grid resilience, and public safety.
- Superconducting microwave frequency filters, already deployed on communication satellites and on 10,000 mobile communication towers to prevent interference among thousands of mobile signals. These filters will be even more important for next-generation mobile networks that will carry much more data at faster speeds.
- Smaller, lighter electrical generators built with superconducting cables. These are being considered for deployment on massive off-shore wind turbines, which would lower costs and make installation easier.

The Takeaway

Sustained research over decades has yielded insights that transform a mysterious phenomenon into practical and valuable technologies. Continuing research is likely to lead to a better understanding of superconductivity and, perhaps, even more useful applications.

Adapted from chapter 3 of A Remarkable Return on Investment in Fundamental Research, U.S. DOE, June 2018.
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