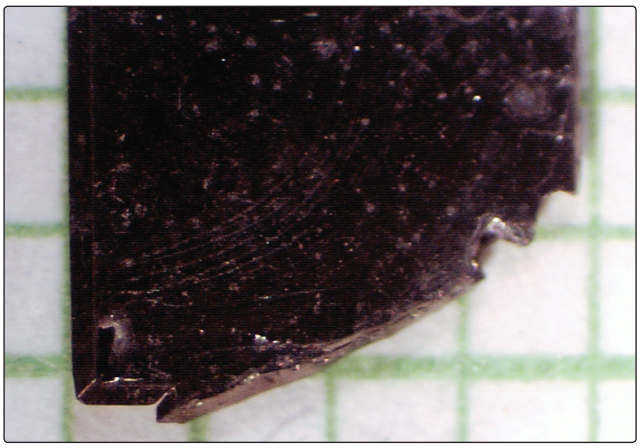
Heating up the search for zero-resistance transmission

SUPERCONDUCTORS, MATERIALS THAT HAVE ZERO RESISTANCE AT low temperatures, have the potential to dramatically increase the energy efficiency of high-field magnets – like those in the MRI machines found in most hospitals – and to improve the power grid in surge protection and even, possibly, electrical transmission lines. But what is needed to make this happen is the design, discovery, and, ultimately, control over a superconducting material that carries a high current densities in high magnetic fields and requires little cost and cooling.



An iron-arsenic crystal grown by Ames Laboratory senior physicist Paul Canfield's crystal-growth group.

The 2008 discovery of a new type of superconductor based on iron and arsenic sparked a fast-paced, worldwide race to understand, modify and control iron-arsenic superconductors. Ames Laboratory scientists have been right in the thick of things, discovering new compounds and properties, and leading several parts of the effort to characterize and improve these complex compounds. Ames Laboratory scientists have racked up an impressive list of firsts including the first growth and characterization of single crystals of several classes of iron-arsenic compounds; the first discovery of pressure induced superconductivity; and the first experimental determinations of electronic structure and magnetic anisotropy, both of which indicate that these materials may well become practical superconductors.

Within the span of about a year, Ames Laboratory researchers have once again done that at which they excel: they have used the intellectual as well as material resources uniquely available within a national lab setting to assemble a focused, multidisciplinary team to address key problems associated with a new and vital material. Since 2008, nearly 70 scientific papers have been submitted to journals, with over half of them published, drawing over 1,000 citations.

Designing superconducting fault-current limiters

AS DEMAND FOR ELECTRICITY IN URBAN AREAS GROWS, POWER transmission lines are increasingly strained by growing currents. Fault-current limiters protect power grids from sudden spikes in power, much like household surge protectors save televisions and computers from damage during a lightning strike. Superconductors enable a novel and promising type of fault-current limiter — or "firewall" — that rapidly switches to a resistive state when the current exceeds the superconductor's critical current. At the same time, in normal operation, the superconductor's near-zero AC resistance minimizes power loss and makes the fault-current limiter effectively "invisible" in the electric grid.

Ames Laboratory physicist John Clem has developed a theory that identifies a design strategy to reduce costs and improve efficiency in bifilar fault-current limiters, a new and promising type of superconducting fault-current limiter being developed by Siemens and American Superconductor Corp. Clem's work, funded by the Department of Energy's Office of Science, Basic Energy Sciences Office, shows how to predict changes in AC losses in relationship to changes to components in fault-current limiters.

"My theoretical work shows that the AC losses in bifilar fault-current limiters could be reduced by using wider superconducting tapes," says Clem. "This may encourage American Superconductor to manufacture a new line of products."

Research by Ames Laboratory physicist John Clem will help protect power-grid transmission lines from sudden power spikes.