'Single-Crystal' Superconductors are a Big Step for the Field

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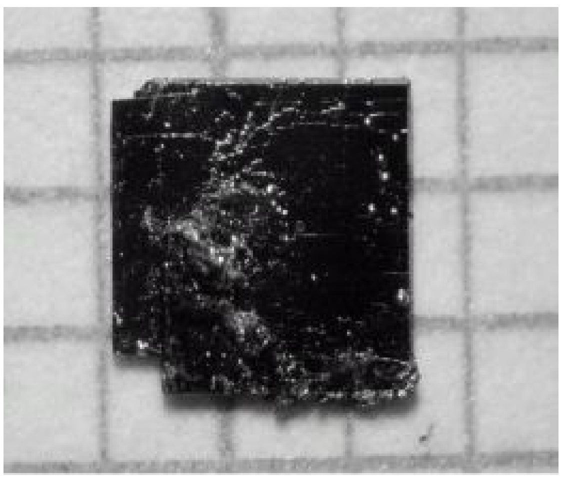

A sample of a potassium-doped iron arsenide superconductor, shown on a millimeter grid. Image courtesy the American Physical Society [N. Ni et al. (10 July 2008). Anisotropic thermodynamic and transport properties of single-crystalline Ba1?xKxFe2As2 (x=0 and 0.45). Physical Review B, Vol 78, p014507, Fig 1]

(PhysOrg.com) -- In key advances for the field of superconductivity, a research group has created versions of a class of widely studied superconducting compounds that are each one continuous crystal, rather than composed of many crystalline grains. These single-crystal materials are important achievements because they display better properties than polycrystalline types and are easier to study.

In a series of four recent papers, three published in *Physical Review B* and one in *Physical Review Letters,* the researchers describe the process they developed to "grow" the single-crystal materials. They also lay out the basic but vital measurements they performed on them, including their molecular structures and how they transport charge.

The group, which includes scientists from Ames Laboratory in Iowa, Iowa State University (ISU), and San Diego State University, created single-crystal versions of two iron arsenide superconductors, a class of superconductors currently being examined by researchers across the globe. However, most of these researchers are studying polycrystalline varieties, with only recent work coming out on single crystals.

The first paper[1] describes the barium/iron/arsenic superconductor $BaFe_2As_2$ and a compound derived from it that contains a slightly different amount of barium as well as small amounts of potassium (The potassium, in this context, is a "dopant" material that bolsters the material's properties. Doping is common in superconductivity research.)

"Growing single-crystal versions of these materials allows us to study their 'anisotropic' superconducting properties—their tendency to display superconductivity along one axis but not others," said the group's spokeperson, Ames Lab and ISU scientist Paul Canfield, to *PhysOrg.com.*

The major result published in the first paper is a determination of the highest magnetic field the superconducting state can withstand (called the upper critical field) and an evaluation of how anisotropic it is. Some superconductors are extremely anisotropic, and so fully understanding them requires good measurements of this behavior.

Canfield and his group show in their second paper[2] that their single-crystal growth method can be applied to another iron arsenide compound, $SrFe_2As_2$ (where "Sr" is strontium).

And in the third paper[3], the researchers discuss a new member of the iron arsenides. The compound is $CaFe_2As_2$ ("Ca" is calcium) and it had never before been identified as a member of that particular crystallographic family.

"The discovery of $CaFe_2As_2$ was very exciting," said Canfield. "We learned that at a temperature of 170 K [degrees Kelvin, here equal to about -150 degrees Fahrenheit] the material undergoes exceptionally clear changes to its structure and magnetic behavior."

This type of temperature-induced changes are known as "first-order" transitions, and understanding how they occur—a task made easier when the changes are obvious—will aid in scientists' knowledge of superconducting materials.

The fourth paper[4] in the series further documents their study of $CaFe_2As_2$, detailing exactly why the material can be classified as a superconducting iron arsenide. The researchers found that at modest pressures the structural and magnetic changes that occur at 170 K are suppressed and the material becomes a superconductor.

"This means that, from a basic science point of view, $CaFe_2As_2$ offers a clean model system that seems to encompass all of the salient features of these compounds (structural, magnetic and superconducting phase transitions) and that its behavior can be tuned with pressure," Canfield said. "This is a very exciting discovery that may help guide the way to understanding this new family of superconductors."

Citations:

[1]Phys. Rev. B 78, 014507 (2008)

[2]Phys. Rev. B 78, 024516 (2008)
[3]Phys. Rev. Lett. 101, 057006 (2008)
[4]Phys. Rev. B 78, 014523 (2008)