Discovery of New Fe-based Superconductor $FeTe_{1-x}S_x$

Nano Frontier Materials Group,
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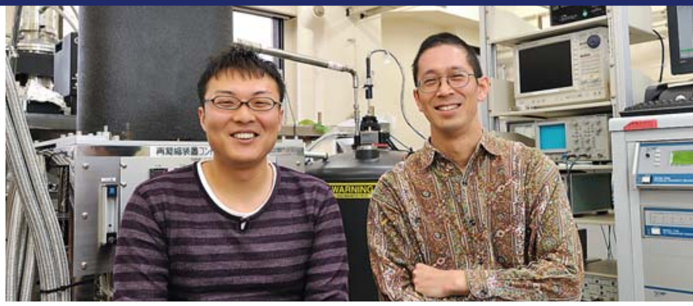

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In February 2008, a group under Prof. Hideo Hosono at Tokyo Institute of Technology discovered that an Fe-As compound, LaFeAsO, displays a superconducting transition at an absolute temperature of 26K. In spite of the fact that the compound contains iron, which had been considered disadvantageous for superconductivity because it is magnetic, this material attracted worldwide attention due its relatively high superconducting transition temperature (T_c) and spurred a boom in research on Fe-based superconductor. Immediately after this discovery, it was found that SmFeAsO, in which La is replaced with Sm, displays an even higher T_c of 55K. As a result, high expectations have been placed on the Fe-based materials as new high temperature superconductors succeeding the copper oxide-based materials.

The crystal structures of the main Fe-based superconductors discovered to date are summarized in **Fig. 1**. Here, (a), (b), and (c) have a common FeAs layer (superconducting layer), and superconductivity occurs in this layer. The T_c of these three materials differs greatly, as the T_c of (a) is 55K, that of (b) is 38K, and that of (c) is 18K, showing that T_c is strongly dependent on the crystal structure between the FeAs layers.

The FeSe in **Fig. 1** (d) is a T_c = 13K superconducting material with a structure that resembles the FeAs layer. We focused on FeSe because it has the simplest crystal structure in Fe-based superconductor, but does not contain arsenic. When the lattice is compressed by applying pressure at approximately 40,000atm, we discovered that the T_c of FeSe increases to 37K, that is the highest class of T_c among the binary superconductors. In addition, our attention was also drawn to FeTe, which does not display a superconducting transition even though its crystal structure resembles that of FeSe. When we replaced the Te site with 20% S, which has a small ion radius, we made the new discovery that $FeTe_{0.8}S_{0.2}$ displays superconductivity when the lattice is slightly compressed.

One of the attractive features of Fe-based superconductor is the diversity of superconducting layers. In addition to the FeAs, FeP, and FeSe layers which were discovered previously, we found that the FeTe layer also shows superconductivity. In the future, it may be possible to realize even higher superconducting transition temperatures than those to date if superconducting layers with new structures and new combinations of elements can be discovered. Thus, research on Fe-based superconductor truly has great potential.

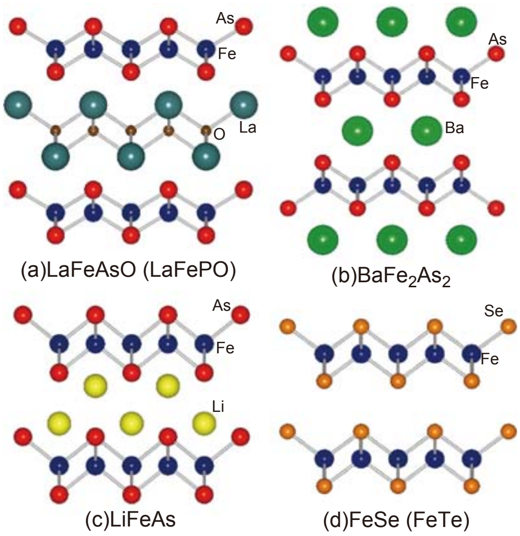

Fig.1 Crystal structures of various Fe-based superconductors. The respective T_c are (a) 55K, (b) 38K, and (c) 18K. The T_c of (d) FeSe is 13K, but this increases to 37K under pressure.

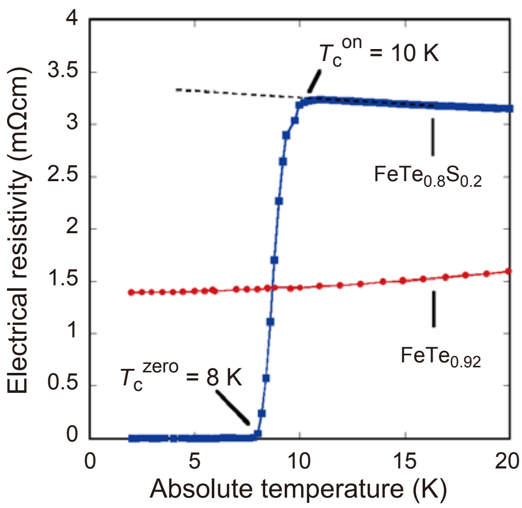

Fig.2 Temperature dependence of electrical resistivity in $FeTe_{0.8}S_{0.2}$. A zero resistance state was observed at temperatures of approximately 8K and below.