PC2-1-INV

New iron-based superconductors with separate double FeAs Layers

*Guang-Han Cao[1], Zhi-Cheng Wang[1], Si-Qi Wu[1], Chao-Yang He[1]

Department of Physics, Zhejiang University, Hangzhou 310027, China[1]

In the view of crystal structure, cuprate and iron-based superconductors contain quasi-two-dimensional CuO_2 planes and FeAs layers, respectively, which play the decisive role for high-temperature superconductivity. In iron-based superconductors, the FeAs/Se layers are either separated each other to form a single-layer compound (e.g., LaFeAsO), or connected by monatomic layer to form an "infinite-layer" material (e.g., $BaFe_2As_2$), or simply stacked together with van de Waals force (e.g., FeSe). Are there any analogs of double-CuO2-layer or multi-CuO_2-layer materials in iron-based systems?

In a paper published four years ago [1], we proposed an intergrowth structure which contains separate double-FeAs layers. Recently, motivated by the discovery of "1144-type" iorn-based superconductors [2], we succeeded in synthesizing the target compound ($KCa_2Fe_4As_4F_2$) for the first time [3]. The double FeAs layers are connected by K+, which are separated by the insulating Ca_2F_2 layers. The material itself is almost optimally hole doped, making it superconducting (at 33 K) without extrinsic chemical doping.

We also tried to expand this 12442-type family of iron-based superconductors. We find that the lattice match is crucial for the intergrowth structure. The tolerance of lattice mismatch is about 2% for the synthesis under ambient pressure. So far we have obtained 18 new superconductors in the 12442 family whose T_c values span from 28 to 37 K [4]. The possible structural correlations with T_c will be discussed in the talk.

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Keywords: Iron-based superconductors, Lattice match, Crystal structure

PC2-2-INV

X-ray fluorescence holography of $Ca_{1-x}Pr_xFe_2As_2$

*Kazutaka Kudo[1], Satoshi Ioka[1], Naohisa Happo[2], Hiromi Ota[3], Yoshihiro Ebisu[4], Koji Kimura[5], Takuma Hada[2], Takumi Kimura[1], Hiroo Tajiri[6], Shinya Hosokawa[7], Kouichi Hayashi[5], Minoru Nohara[1]

Research Institute for Interdisciplinary Science, Okayama University, Japan[1]
Graduate School of Information Sciences, Hiroshima City University, Japan[2]
Advanced Science Research Center, Okayama University, Japan[3]
Graduate School of Science and Technology, Hiroshima Instituite of Technology, Japan[4]
Department of Physical Science and Engineering, Nagoya Institute of Technology, Japan[5]
Japan Synchrotron Radiation Research Institute, Japan[6]
Department of Physics, Kumamoto University, Japan[7]

The state-of-the-art technique, x-ray fluorescence holography experiment [1], was performed in order to visualize the local 3D atomic configurations and positional fluctuations [2] of iron-based superconductor $Ca_{1-x}Pr_xFe_2As_2$. The compound has been reported to exhibit high superconducting transition temperature T_c = 49 K with a very small superconducting volume fraction of several percent [3,4]. STM/STS observed a large superconducting gap around the doped Pr atoms, but no superconducting gap was observed around Ca [5]. In order to investigate the reason why the high T_c superconductivity emerges around Pr, we performed x-ray fluorescence holography experiments using synchrotron radiation at BL13XU, SPring-8, Japan and reconstructed the atomic images around Ca and Pr atoms from the holograms.

The atomic images of As revealed that As positions fluctuated significantly even in the parent $CaFe_2As_2$ compound without Pr doping. For Pr-doped $Ca_{0.9}Pr_{0.1}Fe_2As_2$, we found that the positional fluctuations of As were almost unchanged around Pr atoms compared with $CaFe_2As_2$, but the positional fluctuations of As were significantly increased around Ca atoms, which were located far from doped Pr. These observations were consistent with the local superconductivity at T_c = 49 K around the doped Pr.

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Keywords: iron-based superconductors, chemical substitution, local structure, x-ray fluorescence holography

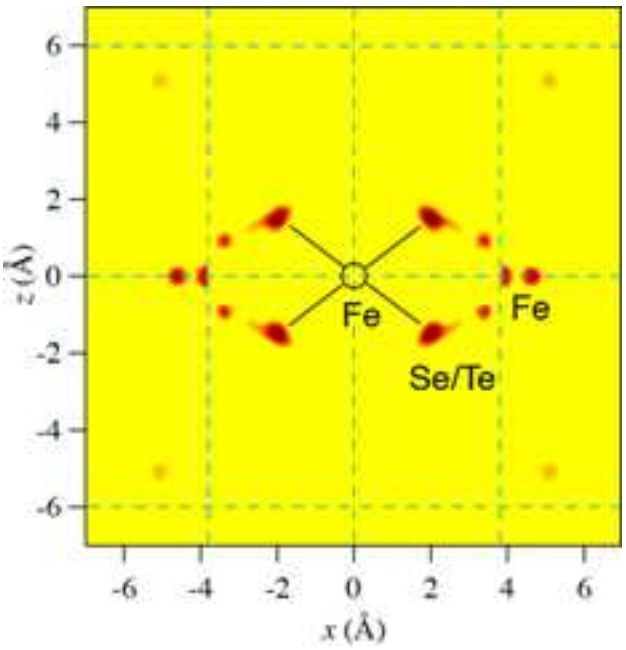
PC2-3

An X-ray Fluorescence Holographic Study on a Fe-based High-Temperature Superconductor $FeSe_{0.4}Te_{0.6}$

*Jens R. Stellhorn[1], S. Hosokawa[1], N. Happo[2], K. Kimura[3], K. Hayashi[3], H. Okazaki[4], A. Yamashita[4], Y. Takano[4]

Department of Physics, Kumamoto University, Kumamoto 860-8555, Japan[1]
Graduate School of Information Sciences, Hiroshima City University, Hiroshima 731-3194, Japan[2]
Department of Physical Science and Engineering, Nagoya Institute of Technology, Nagoya 466-8555, Japan[3]
MANA, National Institute for Materials Science, Tsukuba 305-0047, Japan[4]

$FeSe_xTe_{1-x}$ is one of the simplest Fe-based superconductors, and has intensively been studied concerning the interplay between structural or magnetic degrees of freedom and superconductivity. $FeSe_{0.4}Te_{0.6}$ has a layered structure in which the layers of Fe atoms and Se/Te atoms overlap each other. To understand the superconductivity of $FeSe_{0.4}Te_{0.6}$, it is necessary to independently reveal the local structures around the Fe and chalcogen atoms.
The x-ray fluorescence holography (XFH) [1] is a newly developed technique that enables one to draw three-dimensional (3D) atomic images around a specific element emitting fluorescent x-rays. We have performed Fe and Se Kα XFH measurements on a $FeSe_{0.4}Te_{0.6}$ single crystal at 100K. Figure 1 shows the atomic image around the Fe central atom on the (010) plane. As seen in the figure, the images of the nearest-neighboring Se/Te atoms have an oval form with a tail towards the larger x direction. This observation is supported by x-ray absorption fine structure (XAFS) measurements, which have also been conducted at the same temperature. The XAFS results indicate that the Se/Te atoms are considerably displaced from their ideal position and exhibit large positional fluctuations. The x-ray [2] and neutron [3] diffraction results, on the other hand, indicate only slightly different z values for Se and Te, respectively. It should be also noted that the second neighboring Fe images are separated into four, suggesting a large lattice distortion in the crystal.



Keywords: High-temperature superconductor, Holography, Atomic image

PC2-4

Evolution of Physical Properties in FeSe Single Crystals with Different Qualities

*Tsuyoshi Tamegai[1], Jingting Chen[1], Sunseng Pyon[1], Yue Sun[2]

Department of Applied Physics, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-8656, Japan[1]
Institute for Solid State Physics (ISSP), The University of Tokyo, Kashiwa, Chiba 277-8581, Japan[2]

FeSe attracts a lot of attention because of its unique nature with nonmagnetic nematic state coexisting with superconductivity, close proximity to BCS-BEC crossover regime with its small Fermi energy, and possibility of extremely high superconducting transition temperature (T_c) [1]. This is backed up by recent developments of crystal-growth technique using KCl/$AlCl_3$ mixtures with a low melting temperature [2]. Using technique, we have successfully grown FeSe single crystals with a wide range of superconducting transition temperatures (T_c) between 9.1 K and 5.5 K. Systematic studies have been performed on their transport, magnetic, structural, and thermal properties. As the T_c is suppressed, residual resistivity increases and the magnitude of magnetoresistance decreases. On the other hand, crossover from low-field quadratic to high-field linear magnetic field dependence is observed in all FeSe crystals, indicating the presence of Dirac Fermions. In addition, specific heat measurements demonstrate the presence of multiple gaps in all FeSe crystals. The temperature dependence of specific heat can be well fitted by the combination of a large isotropic *s*-wave gap and a small anisotropic *s*-wave gap. In FeSe with the highest T_c, the anisotropy of the small gap becomes the largest. This is consistent with the recent angle-resolved specific heat measurements on the same piece of crystal showing a clear four-fold angular dependence [3].

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Keywords: FeSe, Specific Heat, Multi-gap Superconductivity, Dirac Fermion

PC2-5

Electrotransport and magnetic measurements on bulk FeSe superconductors

Thomas Karwoth[1], Kouichi Furutani[1,2], *Michael R Koblischka[1,2], Xianlin Zeng[1], Alex Wiederhold[1], Miryala Muralidhar[2], Masato Murakami[2], Uwe Hartmann[1]

Experimental Physics, Saarland University, Campus C 6 3, 66123 Saarbrücken, Germany[1]
Superconducting Materials Laboratory, Department of Materials Science and Engineering, Shibaura Institute of Technology, Tokyo 135-8548, Japan[2]

The superconducting properties of bulk, polycrystalline FeSe samples were characterized through magnetic and electric transport measurements. In order to improve the superconducting properties, the sintering temperature was varied up to 900 °C and to improve the grain connectivity, silver was applied in low concentrations to the samples ranging from 0 to 7 wt.-%. The electric properties of the samples were investigated by the four point probe method (*R-T* measurements and *V-I* characteristics). Generally, the sample with 4 wt.-% Ag-addition showed showed the highest critical transition temperature among all the samples fabricated with the same preparation parameters. The critical currents were estimated from *V-I* measurements in various applied magnetic fields up to 6 T. Via Arrhenius plots, the pinning potential U_0 was determined for all samples studied. The magnetic properties (*M-T* and *M-H*) of the samples were measured using an extraction magnetometer in a Quantum Design PPMS with applied magnetic fields up to 7 T. The scaling of the normalized volume pinning force versus the reduced field indicated a peak position at 0.4 for the pure FeSe sample sintered at 900 °C, which points to a δT_c-pinning type. The improved flux pinning and the high critical current densities are attributed to the textured microstructure of the material.

Keywords: FeSe, I-V characteristics, pinning, critical current

PC2-6

Epitaxial NdFeAs(O,F) Films By Molecular Beam Epitaxy: Influence Of Film Thickness And Surface Morphology On Superconducting Properties

*Sandra Kauffmann-Weiss[1], Kazumasa Iida[2,3], Takuya Matsumoto[3], Taito Ohmura[2], Takafumi Hatano[2,3], Torben Boll[4,5], Marco Langer[1], Bernhard Holzapfel[1], Hiroshi Ikuta[2,3], Jens Hänisch[1]

Institute for Technical Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany[1]
Department of Crystalline Materials Science, Nagoya University, Chikusa-ku, Nagoya 464-8603, Japan[2]
Department of Materials Physics, Nagoya University, Chikusa-ku, Nagoya 464-8603, Japan[3]
Karlsruhe Nano Micro Facility, Karlsruhe Institute of Technology, 76344, Eggenstein-Leopoldshafen, Germany[4]
Institute for Applied Materials, Karlsruhe Institute of Technology, Karlsruhe, Germany[5]

The Fe-based superconductors, such as *Ln*FeAs(O,F) (*Ln*=lanthanide) and related compounds, represent a new class of superconductors exhibiting the highest critical temperature (T_c) apart from the cuprates. Due to relative high anisotropies of *Ln*FeAs(O,F) combined with the intrinsic pinning, the critical current density J_c in high magnetic fields exhibits a strong angular dependence with regard to the magnetic field orientation. These unconventional superconductors are interesting not only from a fundamental research point of view, but also with regard to possible sensor applications. For such applications, however, thin films with a smooth surface and high T_c are necessary. With this respect, we comparatively investigate the microstructure – transport property relationships of $NdFeAsO_{1-x}F_x$ thin films and NdFeAsO/NdOF compounds, grown with several thicknesses by molecular beam epitaxy (MBE) on MgO(001) substrates. The (micro) structure was investigated by X-Ray diffraction as well as atomic force and scanning electron microscopy and atom probe tomographyic. Superconducting properties were determined by electrical transport measurements. We show how film thicknesses, structure, surface morphology and growth defects influence the resistive transition and T_c as well as temperature, field and orientation dependencies of J_c. For a 20 nm thin $NdFeAsO_{1-x}F_x$ film with a root mean square roughness < 2nm a high transition temperature of $T_{c,0} = 44.7$K and $T_{c,onset} = 48$K could be observed which is close to values measured on single crystals.
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Keywords: NdFeAsO1-xFx, MBE, surface morphology