**I. INTRODUCTION**

Superconductivity in the FeAs-based systems has received tremendous attention in last several months with the hope that the superconducting transition temperature could be raised to a higher value. Experimentally, it has been found that the highest $T_c$ is about 55-57 K in the fluorine doped REF $\text{FeAs}_x$ compound, abbreviated as FeAs-32522, or RE doped (Ca,Sr)$\text{FeAsF}$ (RE = rare earth elements). Meanwhile, the family of the FeAs-based superconductors has expanded rapidly. In the system of (Ba,Sr)$_{1-x}$K$_x\text{FeAs}_x$ (denoted as FeAs-122), the maximum $T_c$ at about 38 K was discovered. In the Li$_x$FeAs (denoted as FeAs-111) system, superconductivity at about 18 K was found. In the material FeSe$_{1-x}$ which has no toxic arsenic and a more simple structure, it was shown that the sample became superconductive at about 8 K. By doping or using a high pressure, the $T_c$ can be pushed higher. Superconductivity at about 2.2 K has also been found in a NiP-based layered structure La$_3$NiO$_2$F$_4$ with the inter growth of NiP-111 and 122 building blocks. Very recently, another kind of parent compounds (Sr,Ca,Eu)FeAsF were reported, which may lead to high temperature superconductors by doping charges into the system.

Empirically it is found that the superconducting transition temperature rises when the inter FeAs-layer spacing distance $d_{\text{FeAs}}$ is increased (F-SmFeAsO: $T_c$=55 K, $d_{\text{FeAs}}$=8.7 Å; (Sr,Ba)$_{1-x}$K$_x\text{FeAs}_x$; $T_c$=38 K, $d_{\text{FeAs}}$=6.5 Å; Li$_x$FeAs: $T_c$=18 K, $d_{\text{FeAs}}$=6.4 Å) in the FeAs-based superconductors. Surprisingly this seems to be quite similar to the case in the cuprates. For example, by using the effective layers of CuO planes in the cuprates, superconductors with different structures were discovered. They can be categorized into the so-called single-layer systems La$_{1-x}$Sr$_x$CuO$_4$ and Bi$_2$Sr$_2$CuO$_6$ with the maximum $T_c$ of about 38 K, or the double-layer systems YBa$_2$Cu$_3$O$_7$ and Bi$_2$Sr$_2$CaCu$_2$O$_8$ with the optimal $T_c$ of about 85-92 K, or the triple-layer system Bi$_2$Sr$_2$Ca$_2$Cu$_3$O$_{10}$ with the maximum $T_c$ of about 123 K (at ambient pressure). As inspired by the experience in the cuprate superconductors, a larger separation between the superconducting planes (here the FeAs layers) may lead to a higher $T_c$. Thus it becomes very interesting to see whether it is possible to fabricate a compound with larger spacing distance between the FeAs-planes. In this paper, we report the discovery of another kind of FeAs-based layered compound (Sr$_3$Sc$_2$O$_5$)$_2\text{Fe}_2\text{As}_2$ (abbreviated as FeAs-32522), which has an inter FeAs-layer spacing distance of about 13.438 Å, being much larger than those in all other parent compounds discovered so far, such as REF $\text{FeAs}_x$, FeAs-122, and (Sr,Ca,Eu)FeAsF. The temperature dependence of resistivity, magnetization, Hall effect and magneto-resistance all exhibit quite similar behaviors as other parent compounds, but with the exception that the resistivity anomaly which was associated with the SDW/structural transition has not been found in present system up to 400 K. Superconductivity may be induced by doping electrons or holes in this new compound.
II. EXPERIMENT

The compound Sr$_3$Sc$_2$O$_5$Fe$_2$As$_2$ was found while looking for iron arsenic analogs of materials with this structure type seen in related chemical systems. The polycrystalline samples were fabricated by using a two-step solid state reaction method. Firstly, SrAs and ScAs powders were obtained by the chemical reaction method with Sr pieces, Sc pieces and As grains. Then they were mixed with Sc$_2$O$_3$ (purity 99.9%), SrO (purity 99%), Fe$_2$O$_3$(purity 99.9%), and Fe powder (purity 99.9%) in the formula (Sr$_3$Sc$_2$O$_5$)Fe$_2$As$_2$, grounded and pressed into a pellet shape. The weighing, mixing and pressing processes were performed in a glove box with a protective argon atmosphere (the H$_2$O and O$_2$ contents are both below 0.1 PPM). The pellets were sealed in a quartz tube with 0.2 bar of Ar gas and followed by a heat treatment at 1000 °C for 40 hours. Then it was cooled down slowly to room temperature.

The X-ray diffraction (XRD) pattern of our samples was carried out by a Mac-Science MXP18A-HF equipment with $\theta$–$2\theta$ scan. The XRD data taken using powder sample was analyzed by the Rietveld fitting method using the GSAS suite. The starting parameters for the fitting were taken from isostructural (Sr$_3$Sc$_2$O$_5$)Cu$_2$S$_2$ and the program will finally find the best fitting parameters. The dc magnetization measurements were done with a superconducting quantum interference device (Quantum Design, SQUID, MPMS7). For the magnetotransport measurements, the sample was shaped into a bar with the length of 3 mm, width of 2.5 mm and thickness of about 0.8 mm. The resistance and Hall effect data were collected using a six-probe technique on the Quantum Design instrument physical property measurement system (PPMS) with magnetic fields up to 9 T. The electric contacts were made using silver paste with the contacting resistance below 0.06 Ω at room temperature. The data acquisition was done using a dc mode of the PPMS, which measures the voltage under an alternative dc current and the sample resistivity is obtained by averaging these signals at each temperature. In this way the contacting thermal power is naturally removed. The temperature stabilization was better than 0.1% and the resolution of the voltmeter was better than 10 nV.

III. ANALYSIS TO THE STRUCTURAL DATA

The XRD pattern for the sample (Sr$_3$Sc$_2$O$_5$)Fe$_2$As$_2$ is shown in Fig. 2. One can see that the sample is very pure since no any visible peaks can be detected from the impurity phase. The data was well fitted with a single tetragonal (Sr$_3$Sc$_2$O$_5$)Fe$_2$As$_2$ phase with the space group of $I4_1/mmm$. Rietveld refinement shown by the solid line in the figure gives good agreement between the data and the calculated profiles. Lattice parameters for the tetragonal unit cell was determined to be $a = 4.069$ Å and $c = 26.876$ Å. In Table I, the structure parameters, angles of As-Fe-As and Fe-As-Fe (as marked in Fig.1) were listed with agreement factors: $wR_p = 11.75\%$, $R_p = 8.09\%$.

It is clear that the a-axis lattice constant of this parent phase is slightly larger than that of the REF$_4$O$_5$, (Ba,Sr)Fe$_2$As$_2$ and (Sr,Ca,Eu)FeAsF systems, while the c-axis one is much larger. The skeleton shown in the right hand side of Fig.1 gives the structure model of our sample. It is clear that the Fe ions construct a square lattice and the FeAs-layer stacks with the (Sr$_3$Sc$_2$O$_5$) building block along c-axis. The spacing distance between two neighboring FeAs-layers of about 13.438 Å is much larger than those in all other FeAs-based compounds discovered so far, such as REF$_4$O$_5$, (Ba,Sr)Fe$_2$As$_2$, and (Sr,Ca,Eu)FeAsF. This may induce high $T_c$ superconductivity by doping charges into the system. In fact, this kind of structures...
FIG. 2: (Color online) X-ray diffraction patterns and the Rietveld fit for the (Sr$_3$Sc$_2$O$_5$)Fe$_2$As$_2$ powder sample.

TABLE I: Fitting parameters, some angles (°) for (Sr$_3$Sc$_2$O$_5$)Fe$_2$As$_2$. $wR_p = 11.75\%$, $R_p = 8.09\%$.

| Atom site | x   | y   | z   | B    | angle (°) |
|-----------|-----|-----|-----|------|-----------|
| Sc        | 0   | 0   | 0   | 0.07399(12) | 0.28(6)   |
| Fe        | 0.5 | 0   | 0.25 | 0.46(6) |           |
| Sr        | 0   | 0.5 | 0   | 1.2(5)  |           |
| Sr        | 0   | 0.5 | 0.14006(6) | 0.51(4) |           |
| As        | 0   | 0   | 0   | 0.20018(6) | 0.62(4)  |
| O         | 8g  | 0.5 | 0.08323(23) | 0.54(14)|           |
| O         | 2a  | 0   | 0   | 0.82(31)|           |
| $\alpha$ |     |     |     |       | 113.30(7)° |
| $\beta$  |     |     |     |       | 107.590(32)° |
| $\gamma$ |     |     |     |       | 72.410(32)° |
| $\delta$ |     |     |     |       | 113.30(7)° |

were reported and classified to the general formula (Cu$_2$S)$_2$(Sr$_{n+1}$M$_n$O$_{3n-1}$)$_{19}$.

IV. ELECTRICAL AND MAGNETIC PROPERTIES

In Fig. 3 (a) we present the temperature dependence of resistivity for the (Sr$_3$Sc$_2$O$_5$)Fe$_2$As$_2$ sample under two magnetic fields 0 T and 9 T. The data under zero field were collected in temperature region up to 400 K. A weak upturn in the low-temperature regime can be seen, representing a weak semiconductor-like behavior for the present sample. This behavior was attributed to the weak localization effect in our sample.

Interestingly, the similar weak upturn of resistivity was observed in stoichiometric LaOFeP$_{23}$. A metallic behavior can be seen in the temperature dependence of resistivity in the temperature regime above 60 K in our sample.

Surprisingly, no resistivity anomaly corresponding to the SDW transition was observed up to 400 K. This can be further confirmed by the magnetization data as shown in Fig. 3 (b), which shows the zero field cooled dc magnetization at 5000 Oe. Again no anomaly was observed in the magnetization data. This is rather different from other FeAs-based parent compounds, such as REFeAsO$_3$, (Ba,Sr)Fe$_2$As$_2$$_5$, and (Sr,Ca,Eu)FeAsF$_{13}$, where clear resistivity and magnetization anomaly associated with the SDW/structural transition have been observed. We attribute it to the rather large spacing distance between the neighboring FeAs-layers in the present system, which prevents from forming the anti-ferromagnetic correlation between the moments of Fe ions in neighboring FeAs-layers.

To further understand the conducting carriers in the present sample, we also carried out the Hall effect measurements on the present sample. The inset of Fig. 4 shows the magnetic field dependence of Hall resistivity ($\rho_{xy}$) at different temperatures. In the experiment, $\rho_{xy}$ was taken as $\rho_{xy} = [\rho(+H) - \rho(-H)]/2$ at each point to eliminate the effect of the misaligned Hall electrodes.
It is clear that $\rho_{xy}$ is negative at all temperatures below 300 K for (Sr,Sc)Fe$_2$As$_2$ leading to a negative Hall coefficient $R_H = \rho_{xy}/H$. This is similar to that of REFeAsO and (Ba, Sr)Fe$_2$As$_2$ parent phases, but in sharp contrast with (Sr, Ca, Eu)FeAsF in which the positive Hall coefficient $R_H$ was found. The temperature dependence of the Hall coefficient $R_H$ is presented in the main frame of Fig. 4. One can see that $R_H$ remains negative in wide temperature regime up to 300 K and the absolute value of $R_H$ decreases monotonically from 2 K to 300 K. This indicates that electron-type charge carriers dominate the conduction in the present sample. The strong temperature dependent behavior of the Hall coefficient $R_H$ suggests either a strong multi-band effect or a spin related scattering effect. The absolute value of $R_H$ is remarkably smaller than that of SrFeAsF system, indicating a relatively higher density of charge carriers.

The magnetoresistance (MR) is a very powerful tool to investigate the properties of electronic scattering. Field dependence of MR for the present sample at different temperatures is shown in the main frame of Fig 5. One can see a systematic evolution of the curvature in the $\Delta \rho/\rho_0$ vs H curve, where $\Delta \rho = \rho(H) - \rho_0$, $\rho(H)$ and $\rho_0$ represents the longitudinal resistivity at a magnetic field $H$ and that at zero field. The MR data at 2 K is positive with a hump shape below 2.3 T and becomes negative at higher fields. While at 5 K, a maximum value of MR appears at about 3.3 T and it decreases until becoming zero at 9 T. The data at 10 K have a downward curvature compared with that measured at higher temperatures. We attribute the complicated behavior at low temperatures, especially the negative MR effect at 2 K, to the Kondo effect which is associated very well with the upturn of resistivity or the magnetic susceptibility, or to the magnetic field induced delocalization effect. The semiclassical transport theory has predicted that the Kohler’s rule will be held if only one isotropic relaxation time is present in a solid state system. The Kohler’s rule can be written as

$$\frac{\Delta \rho}{\rho_0} = \frac{\rho(H) - \rho_0}{\rho_0} = F\left(\frac{H}{\rho_0}\right).$$

This equation means that the $\Delta \rho/\rho_0$ vs $H/\rho_0$ curves for different temperatures, the so-called Kohler’s plot, should be squared to a universal curve if the Kohler’s rule is obeyed. The scaling based on the Kohler plot of our sample is revealed in the inset of Fig 5. An obvious violation of the Kohler’s rule can be seen from this plot. This behavior may indicate a multi-band effect or a complicated scattering mechanism, like the Kondo effect or the weak localization in the low temperature region. This kind of upturn of resistivity and the magnetic susceptibility in the low temperature limit seem to be common features for the parent phases of the FeAs-based compounds and further studies are certainly required to unravel the underlying physics.

V. CONCLUDING REMARKS

In summary, a parent phase of the FeAs-based family, (Sr, Sc)Fe$_2$As$_2$, with the space group of $I4/mmm$ was synthesized successfully using a two-step solid state reaction method. Rather large spacing distance between the neighboring FeAs-layers was found. No anomaly associated with the AF order was observed either in the data.
of temperature dependence of resistivity or dc magnetization, which was attributed to the rather large spacing distance between the neighboring FeAs-layers. Strong Hall effect was observed in the temperature region up to 300 K. We found that the Hall coefficient $R_H$ is negative in the entire temperature regime. We also observed a de-localization effect at low temperatures from the MR data. The violation of the Kohler’s rule along with the strong localization effect at low temperatures from the MR data. We found that the Hall coefficient $R_H$ is negative in the entire temperature regime. We also observed a de-localization effect at low temperatures from the MR data.

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* Electronic address: hhwen@aphy.iphy.ac.cn

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