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EUASFEO0.85F0.15 SUPERCONDUCTIVITY AND MAGNETIC CHARACTERISTICS

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Abstract

EuAsFeO0.85F0.15 with a critical temperature Tc 11K was synthesised in a solid-state synthesis process. In magnetic fields ranging from 0.1 to 140000 Oe, its electric and magnetic characteristics have been studied. Magnetic penetration depths and coherence lengths have been determined by measuring critical magnetic fields Hc1 and Hc2. At low temperatures, the temperature dependency Hc2 (T) shows evident hyperbolic-like behaviour. It was found that compounds doped with rare-earth elements that have tiny atomic radii had higher than average concentrations of Tc and Hc2. The PACS score is 74.70. Ads * Please use the following address for any correspondence: dmitriev@ilt.kharkov.ua. Special properties of rare-earth metals, include superconductivity and magnetism

Introduction

It was first reported in 2008 that LaFeAsO1-xFx was superconducting at a temperature of 26K [1]. Ce [2] and Sm [3] replacements soon boosted the critical temperature Tc to 40-43 K, and even to Tc 52K with Nd and Pr [4,5] substitutions. Another interesting fact about the SmFeAsO1- xFx samples was that their superconducting transition temperature was Tc 55 K [6]. As a result, the new category of chemicals may be classified as high-Tc superconductors. The Tc rise seen in rare-earth REBaCuO systems is quite similar to this instance. Furthermore, band-structure predictions and observations show that the novel compounds have a complex mechanism of pairing (called pnictides). Accordingly, it is clear that the inclusion of Fe and Pr in superconducting compounds confirms this view. For example, the La2O2-xFx and Fe2As2 layers in the new superconductors [1] resemble HTSC topologies. Unlike the CuO2 layers in cuprates, which operate as carriers of electron states near the Fermi surface, the FeAs layers act as carriers of current. Charge carriers are provided by the LaOF layers. These compounds, which include rare-earths like Ce and Pr, have been synthesised recently by a variety of organisations.. It has been discovered that the maximum Tc may be achieved in fluorine-containing compounds (x = 0.1-0.2). Tc is also larger for rare-earth elements with lower atomic radii [3]. The study's purpose was to see whether a rare-earth element with a high atomic radius may reduce the REFeAsO1-xFx compound's critical temperature Tc. That the value and temperature dependency of the Hc2 upper critical magnetic field may be affected by this is also fascinating. A typical superconducting magnet may be used to extend the observation of Hc2 (T) behaviour to lower temperatures if Hc2 is much lower than the published data. The atomic radius of Eu is 0.2023 nm, hence we've picked it as our RE ion. To ensure high Tc, atoms of rare-earths have atomic radii in the range of 0.1755 to 0.1855 nm, with F content of 0.1-0.18, the ideal doping.

Experimental details

For 24 hours at T=11500 C, we synthesisedEuAs, EuF3, Fe and Fe2O3 compounds in an ampoule to produce polycrystalline EuAsFeO0.85F0.15. Additionally, the homogenization process was carried out for 30 hours at the same temperature. The electric resistance of the produced superconductors was studied using the four-probe technique in magnetic fields H up to 14 T on 5x1x1 mm samples cut from tablets. Accurate measurements of magnetic AC susceptibility and DC magnetization were made using a PPMS device.

Figure Captions

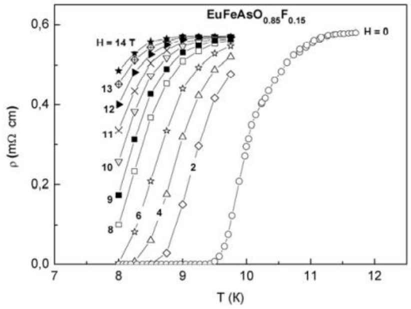
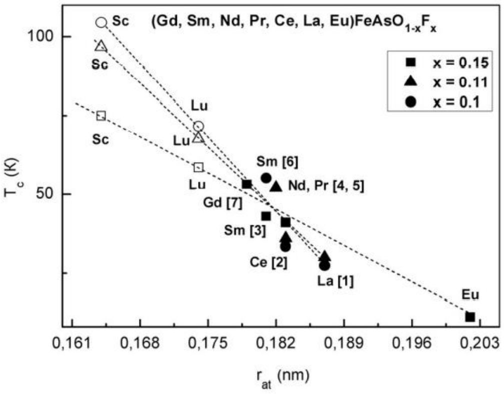
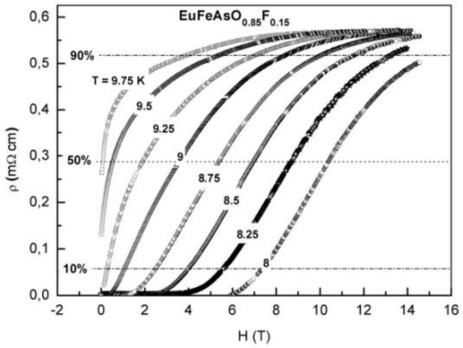


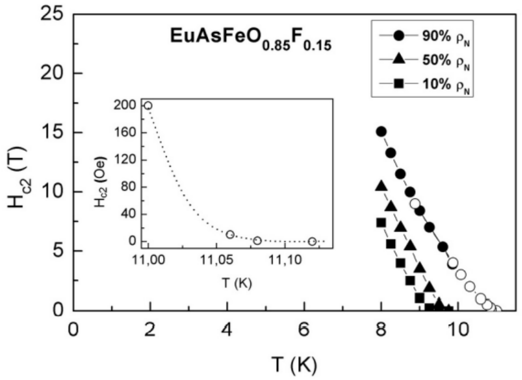
Fig.1. The temperature EuAsFeO0.85F0.15 superconducting resistivity under magnetic fields 0-14T dependences (fields are specified at each curve).



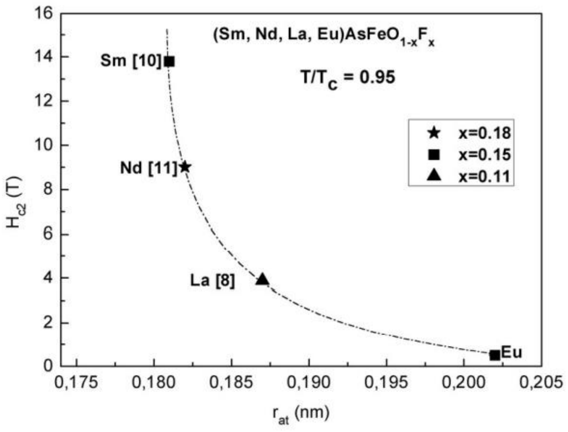
A rare-earth element's atomic radius (rat) affects the critical temperature (Tc), as shown schematically in Figure 2 (x=0.1, 0.11, 0.15). The experimental findings from the aforementioned research and from this study are shown by solid symbols. Smaller atomic radii are predicted by open symbols, which are used to represent rare earths.



Temperatures (given at each curve) below the transition point for superconductivity in EuAsFeO0.85F0.15 are presented in Fig.3. (H) values at 10%, 50%, and 90% of the normal resistivity N at T Tc are shown by the dashed horizontal lines.



At the 90 percent, 50 percent, and 10 percent values of N shown in Fig.3, the temperature dependency of the second critical field, Hc2, for EuAsFeO0.85F0.15 was displayed using the data from Fig.3. Magnetic measurements are represented by open symbols, whereas resistance measurements are represented by solid symbols. A low-magnetic field Hc2(T) is shown in the inset (magnetic measurement).



In REAsFeO1-xFx at T/Tc = 0.95, the experimental dependency of Hc2 on the atomic radius of the rare-earths is shown in Fig. 5. In italics, the following is written: sources of knowledge

Results and discussion

Fig. 1 depicts the temperature evolution of electric resistivity approaching the superconducting transition in magnetic fields up to 14T (tesla). Tc onset 11.4 K is the temperature at which the superconducting transition begins. Due to the fact that Eu's atomic radius is much bigger than that of the rare-earth elements previously employed by other researchers, our results preserve the trend that has been documented. To demonstrate this trend, Fig.2 shows Tc and the rare-earth radius as functions of the experimental Tc value (solid symbols). A qualitative prediction is given about the potential Tc-values of rare–earth ions with lower radii (light symbols). Figure 3 depicts the temperature-dependent resistivity of each curve. The horizontal dashed lines indicate the resistivity values that are

10%, 50%, and 90% of the normal value of N. Three Hc2 (T) dependences are shown in Fig.4, which match to the resistivity levels from Fig.3. A magnetometer's readings are shown by circles at the peak of the field curve (see below). This curve is seen in the inset. Hyperbolic-type temperature dependences rather than parabolic ones are evident in all three curves, unlike in conventional, single-gap superconductors. We thus consider that comparing these dependences on the basis of the criteria Hc2(T=0)=-0.693Tc(Hc2/T)T=Tc established for classical superconductors with the parabolic dependence Hc2(T) would be quite unsatisfactory. Aside from the high Hc2(T)-values around Tc, comparing Hc2(0)-values is typically hard due to technological difficulties in the measurement of low-temperature Hc2(T). The Hc2(T)-value recorded at the same relative temperature T/Tc = 0.95 near Tc served as a basis for comparing the findings obtained in this investigation on compounds containing various rare earths. Figure 5 shows the findings as a function of the atomic radius of the rare-earth element. The Hc2(T)-values, like Tc-values, rise when the atomic radius of rare-earths decreases. The new REFeAsO1-xFx – type superconductor may therefore be expected to lead to the development of innovative technologies and strong magnetic fields at high Tc. M′ (a) and M′′ (b) are presented in Figs.6 and 7 for low fields up to 10 Oe and high fields up to 9T, respectively. Observation of the hyperbolic dependency of Hc2 (T) on the superconducting transition temperature shows that even very modest magnetic fields have a significant impact on the transition temperature (see the inset in Fig.4). Hc2(T) dependency may be induced by a multigap Fermi surface [12,13] or other complicated charge and spin interactions. According to these measurements, the start of Tc is around 11 K. The findings of resistance measurements are in excellent agreement with the Hc2(T) dependency in Fig.4 derived from the commencement of the superconducting transition in these magnetic tests. On the basis of data from Figures 6 and 7, Fig.8 depicts our sample EuAsFeO0.85F0.15's magnetic properties up to 9 T. M(H) corresponds to a type II superconductor with a low critical magnetic field Hc1, as seen in the graph. Temperature Hc1 is Hc110 Oe at this temperature (see inset in Fig.8). As a result, we can calculate the magnetic penetration depth based on the known formula Hc1 = ((0 /42)ln(/))/(0/4)ln(n/n). This means that the value of an at T=9K is equal to (T=9K) 60. There are hence 9000 (T=9K). Then, the parameter is equal to / 150. As a result, the new superconductors are hard type II. Hc1(T) and Hc2(T) dependencies at T 0 are unknown, hence usual extrapolation of Hc2 values to T=0 is erroneous in our view.

Conclusions

One additional pnictide-family compound, EuAsFeO0.85F0.15, having a Tc of 11K, has been synthesised. In compared to other known compounds, the EuAsFeO0.85F0.15 compound possesses lower Tc and Hc2 due to Eu's high atomic radius. It is possible to forecast superconducting compounds based on low atomic-radius rare-earths with high Tc and Hc2 at the same time. A conventional 15T magnet would be able to determine the temperature dependency of EuAsFeO0.85F0.15's Hc2. For a T=0 upper critical field estimate, the WHH criteria [9] Hc2(0)=-0.693Tc (H2/T)T – T is insufficient due to the hyperbolic type dependency of Hc2(T) even in low fields (0.1-200Oe). We were able to determine the magnetic field Hc1 at T=9K (T/Tc0.8) using our studies of magnetization in weak fields. The magnetic penetration depth (T=9K) 9000 and the parameter = / 150 were also calculated for this temperature, as were the coherence length (T=9K) 60.

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