



Superconductivity of “1 1 1”-type iron arsenide compounds

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ABSTRACT

“1 1 1”-type iron arsenide compounds AFeAs (A = Li, Na) were synthesized. These compounds crystallize into Cu₂Sb type tetragonal layered structure with space group P4/nmm and show superconductivity with the transition temperature ~18 K for LiFeAs and ~23 K for NaFeAs. The effect of pressure on LiFeAs sample was studied. It was found that the T_c decreased almost linearly with increasing pressure and the pressure derivative dT_c/dP was about -1.38 K/GPa.

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1. Introduction

Since the discovery of superconducting LaFeAsO with T_c 26 K [1], great interests have been stimulated in exploring new superconductors and studying the novel superconducting mechanism in the iron arsenide system. When La atoms are substituted by other rare earth elements, the T_c has been greatly enhanced up to more than 50 K. The RFeAsO (R = rare earth elements, termed “1 1 1 1” type) superconductor has a layered crystal structure belonging to the tetragonal P4/nmm space group. The [LaO] layers are sandwiched between the [FeAs] layers. Soon after the discovery, another type iron based superconductors AFe₂As₂ (A = alkaline earth metal, termed with “122” type) are found, which crystallize into a tetragonal ThCr₂Si₂-type structure [2]. LiFeAs compounds are found to be the third type iron arsenide superconductors (termed “1 1 1” type) [3]. The crystal structures of “1 1 1” type is similar to those of “1 1 1 1” type superconductors with [LaO] layers are substituted by Li layers. Here we report the synthesis and the properties of “1 1 1” type iron arsenide superconductors.

2. Experimental

The polycrystalline samples of nominal composition AFeAs were synthesized by solid state reaction method using Li or Na, FeAs as starting materials. The FeAs precursors were synthesized from high purity Fe and As powders that were sealed into an evacuated quartz tube and sintered at 800 °C for 60 h. The obtained FeAs powder was pressed into pellets. Then the pellets and Li or Na pieces were put into alumina crucible according to nominal formula A_xFeAs (x is 1.2 for Li and 1.5 for Na) and finally sealed in

quartz tubes. They were then sintered at 800–900 °C for 15 h. The reaction products were pressed into pellets after been ground. The pellets wrapped with Ta foil were sealed in quartz tube under Ar. The samples were annealed at 700–800 °C for 30 h again. All preparative manipulations were carried out in a glove box protected with high purity Ar.

The magnetic properties of the samples were measured using a superconducting quantum interference device (SQUID). The resistance was measured by four-probe electrical conductivity methods in a diamond anvil cell made of CuBe alloy.

3. Results and discussion

The “1 1 1”-type AFeAs compounds crystallize into Cu₂Sb type tetragonal layered structure with space group P4/nmm [4], which is shown in Fig. 1. These “1 1 1”-type superconductor have a simple crystal structure that makes them more like an “infinite layer structure” comparing with the prototype ACuO₂ for high T_c cuprate.

Fig. 2 shows the dc magnetic susceptibility for samples of LiFeAs and NaFeAs, which are measured in both zero field cooling (ZFC) & field cooling (FC) mode with a H = 30 Oe. For LiFeAs sample there is a sharp diamagnetic transition at 18 K. While for NaFeAs sample the magnetic susceptibility transition is broad and the diamagnetic transition temperature is about 11 K. The similar behavior was observed by other report [5]. The inset of Fig. 2 shows the difference of FC and ZFC susceptibility for the NaFeAs sample. The temperature where the ZFC and FC curve converges is about 23 K, which is consistent with the T_c suggested by the resistance measurement [6]. So the superconducting transition for the NaFeAs sample might occur at about 23 K.

The pressure dependence of T_c curve for LiFeAs sample is shown in Fig. 3. T_c value decreases linearly with increasing pressure and

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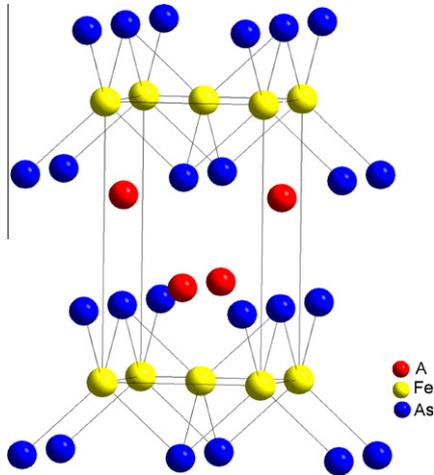


Fig. 1. Crystal structure of “1 1 1” type AFeAs superconductor.

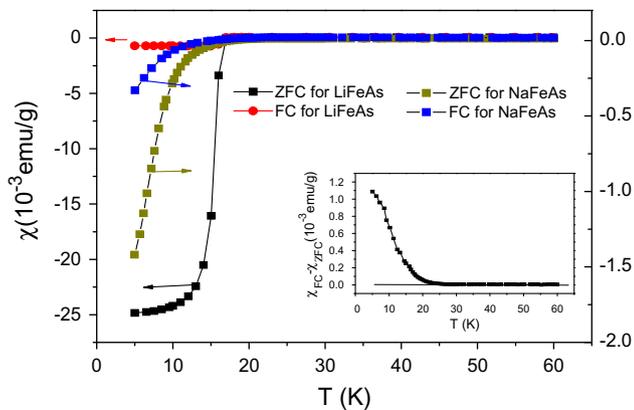


Fig. 2. The dc magnetic susceptibility for superconductors of AFeAs. The inset is the difference of FC and ZFC susceptibility for the NaFeAs sample.

the slope dT_c/dP is -1.38 K/GPa. When pressure is applied to LiFeAs sample, it makes the tetrahedron of FeAs_4 depart from a regular one [7]. Because the density state at the Fermi level in iron arsenide is sensitive to the As–Fe–As angular, there is a strong correla-

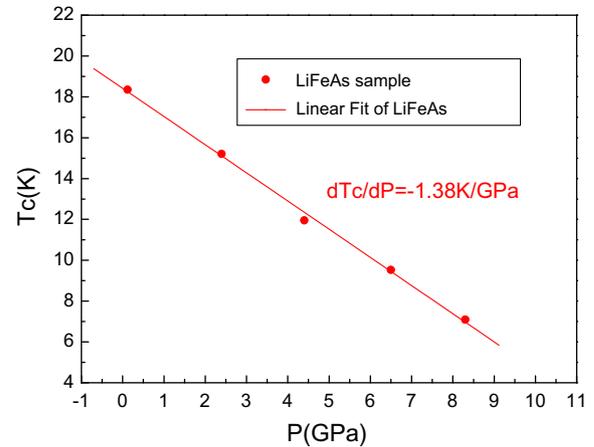


Fig. 3. The pressure dependence of T_c for LiFeAs superconductor.

tion between the shape of FeAs_4 tetrahedra and T_c . In the “1 1 1”-type compounds T_c would reach the maximum value when the FeAs_4 tetrahedron is close to ideal [8]. Deviation from the regular tetrahedron would lower T_c . T_c would be suppressed by pressure since pressure applied to LiFeAs sample increases the deviation of FeAs_4 tetrahedra from ideal geometry.

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