ARTICLE IN PRESS

Journal of Magnetism and Magnetic Materials xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Research articles

Magnetotransport properties of FeSe in fields up to 50 T

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ARTICLE INFO

Article history:
Received 2 July 2017
Received in revised form 10 October 2017
Accepted 26 October 2017
Available online xxxx

Keywords:
High-Tc superconductors
Galvanomagnetic effects
Electronic band structure

ABSTRACT

A study of the magnetotransport properties of a high-quality FeSe crystal in a wide temperature range and in magnetic fields up to 50 T shows that the main electron-like and hole-like bands have very similar values of carrier density and mobility, indicating good electron-hole symmetry in this compound. In addition to the main two bands, there is also a tiny, highly mobile, electron-like band which is responsible for the non-linear behavior of $\rho_{xy}(B)$ at low temperatures and some other peculiarities of FeSe. We observe the inversion of the ρ_{xx} temperature coefficient at a magnetic field higher than about 20 T which is an implicit confirmation of the electron-hole symmetry in the main bands.

1. Introduction

FeSe is a very important and interesting superconducting material with complicated electronic and transport properties [1]. It is a nearly compensated semimetal with low carrier concentration. For the physics of superconductivity, it is a new type of superconducting materials and it is a new playground to test out the existing theories of superconductivity. In particular, the low carrier concentration should have allowed a significant variation of a superconducting transition temperature (T_c) under variation of a carrier concentration. Indeed, it is demonstrated that the transition temperature can be substantially varied using a gate electrode [2]. However the pairing mechanism in FeSe and other iron-based superconductors is still being debated, and the reasons, causing a T_c increase under pressure [3], and for a mono-layer FeSe film on an epitaxial substrate [4], are unclear.

The properties of FeSe, as well as many other iron-based superconductors, cannot be described by the simple two-band model. The first studies of the iron-based superconductors revealed multiband effects and electron-hole asymmetry in $Ba(FeCo)_2As_2$ [5]. Later, an analysis of the magnetic field dependence of ρ_{xy} and ρ_{xx} suggested the presence of the highly mobile electronlike band in $BaFe_2As_2$ [6]. The similar highly mobile band exists in many other iron-based superconductors including FeSe family [7,8] and, apparently, originates from a local region of the Fermi surface. Since the mobilities of the two main bands are several times lower than for the highly mobile band, their properties can be studied separately in a high magnetic field where the conductivity of the highly mobile band is suppressed.

Here we report the magnetotransport properties of the high-quality FeSe crystal measured in a wide temperature range and magnetic fields up to 50 T. The obtained data prove a good symmetry of the main electronlike and holelike bands. A remarkable phenomenon is observed at temperatures below 100 K. All $\rho_{xx}(B)$ curves, corresponding to different temperatures, cross each other in the region 15–20 T and 0.1–0.15 mΩcm. Therefore, a crossover from a metallic-type $\rho_{xx}(T)$ to a semiconductor-type dependence occurs at a magnetic field higher than 20 T. Such behavior has a simple description within the two-band model which gives another way to extract the parameters of the main bands.

2. Experiment

The FeSe crystals were grown using the $KCl/AlCl_3$ flux technique [9]. The chemical composition of the crystals was studied

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https://doi.org/10.1016/j.jmmm.2017.10.108
0304-8853/