High Magnetic Field Investigation of the Collapsed Tetragonal Phase of $CaFe_2As_2$

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Introduction

There are models of superconductivity for FeAs superconductors in which details of the band structure/Fermi surface are considered important [1-2]. For the $Ba(Fe_{1-x}Co_x)_2As_2$ family, the angle-resolved photoemission spectroscopy (ARPES) measurements observed that the onset and the offset of superconductivity occur in proximity to electronic topological transitions, suggesting that superconductivity is connected to the changes in the Fermi surface topology [3]. Among the FeAs-based 122 ($AEFe_2As_2$, AE = Ba, Sr, Ca) family, the $CaFe_2As_2$ appears to be curious one with a different, collapsed tetragonal, phase achievable by application of small (P < 0.5 GPa) hydrostatic pressure [4]. At ambient pressure, the $CaFe_2As_2$ undergoes a structural-magnetic phase transition below 170 K. With increasing pressure, a nonmagnetic collapsed tetragonal phase that is stabilized by 0.3 GPa intersects and terminates the lower pressure orthorhombic-antiferromagnetic phase line as shown in Fig. 1 (a) [5]. Recently, it has been shown that the transition temperature of $CaFe_2As_2$ single crystals grown from excess FeAs can be tuned by annealing or quenching temperature [5]. The Sn-grown single crystal and the FeAs-grown sample that has been annealed at 400 ^oC are quite similar. When the crystals are quenched from 960 ^oC, the phase transition from a high temperature-tetragonal phase to a low temperature-nonmagnetic collapsed tetragonal phase occurs below 100 K. The Fermi surface of the Sn-flux grown $CaFe_2As_2$ crystals has been determined by utilizing the contactless conductivity technique [6]. It would be interesting to compare Fermi surface between orthorhombic-antiferromagnetic phase and a nonmagnetic-collapsed tetragonal phase. Thus, we attempt to detect quantum oscillations in the collapsed tetragonal phase of $CaFe_2As_2$ by means of electrical resistivity and tunnel diode oscillator (TDO, contactless resistivity) measurements in a short-pulsed magnet.

Results and Discussion

Figure 1 (b) shows the magnetoresistance (MR), $\Delta\rho(H)-\rho(0)/\rho(0)$, for the collapsed tetragonal phase of $CaFe_2As_2$. The observed MR is positive and follows H^n with n = 1.8 (see Figure 1 (c)), which is close to the expected value of n = 2 for nonmagnetic metal in a simple one-band model. Although the large MR is obtained at low temperatures, the expected quantum oscillations are not observed in collapsed tetragonal structure from both TDO and resistivity measurements.

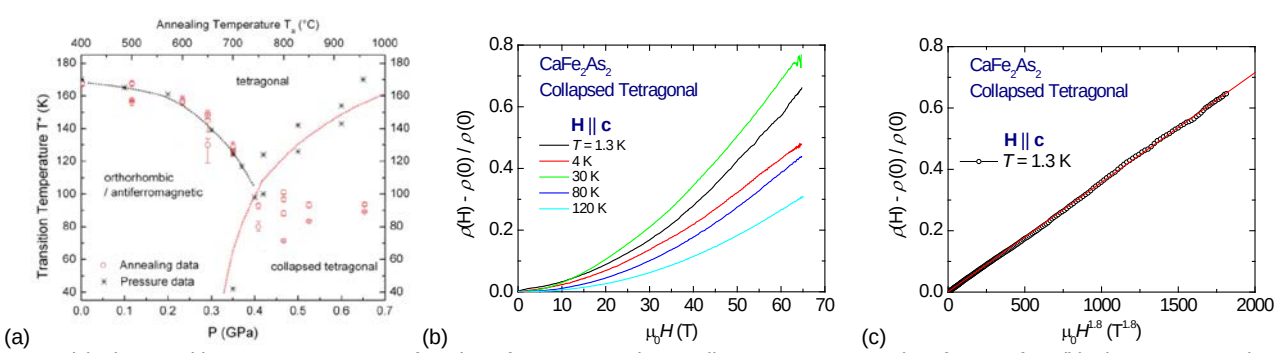

Figure 1: (a) The transition temperatures as a function of pressure and annealing temperatures, taken from Ref. 5. (b) The magnetoresistance of $CaFe_2As_2$ for **H** || c at selected temperatures. (c) MR as a function of $(\mu_0 H)^{1.8}$ at T = 1.3 K.

Conclusions

We have measured the magnetoresistance and contactless resistivity down to 1.3 K and in magnetic field up to 65 T along **H** || **c**. It is found that the observed magentoresistance may be explained by the classical one-band model. The expected quantum oscillations are not detected for the collapsed tetragonal phase of $CaFe_2As_2$. Higher magnetic field up to 100 T and/or much lower temperatures may be required to detect quantum oscillations.

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