Mössbauer studies on FeSe and FeTe

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Article info
Article history:
Accepted 18 November 2009
Available online 24 November 2009

Keywords:
Iron-based superconductor
FeSe
FeTe
Mössbauer
Magnetism

ABSTRACT
We carried out $^{57}$Fe Mössbauer measurements for FeSe and Fe$_{1.08}$Te to investigate the magnetic properties. There was no sign of magnetic ordering above 4.2 K for superconducting FeSe. The magnetic sextet corresponding to antiferromagnetic ordering of Fe in low-spin state was observed for non-superconducting Fe$_{1.08}$Te.

1. Introduction

Since the discovery of LaFeAsO$_{1-x}$F$_x$ superconductor [1], various iron-based superconductors, which have a layered structure analogous to LaFeAsO, have been discovered. Iron-based superconductivity has attracted researchers all over the world due to its high transition temperature $T_c$ under high pressure. The $T_c$ increases from 13 to 37 K [3–5]. NMR measurements indicated an enhancement of antiferromagnetic fluctuations under high pressure where the $T_c$ was dramatically enhanced [6,7]. While FeSe shows high $T_c$, an analogue compound FeTe does not show superconductivity but undergoes antiferromagnetic ordering at 70 K [8–10]. To investigate the magnetic states of FeSe and FeTe, we carried out $^{57}$Fe Mössbauer measurements.

2. Materials and methods

Polycrystalline samples of FeSe and Fe$_{1.08}$Te were synthesized using a solid-state reaction method as described in Refs. [3,10]. The compositions are the starting nominal compositions. The FeSe sample contains a minor-phase hexagonal FeSe, which undergoes magnetic ordering [11]. We carried out the $^{57}$Fe Mössbauer measurements for both FeSe and Fe$_{1.08}$Te from room temperature to 4.2 K.

3. Results and discussion

Fig. 1 shows the $^{57}$Fe Mössbauer spectra of FeSe at 300, 150, 77 and 4.2 K. Major features of the spectra could be explained by a single paramagnetic doublet. For the major phase of superconducting FeSe, the spectrum obtained at 4.2 K showed no sign of magnetic ordering as indicated by red fitting curve. In fact, FeSe does not exhibit magnetic ordering down to 4.2 K while it undergoes a structural transition from tetragonal to orthorhombic around 70 K [12]. The isomer shift (IS) and the quadrupole splitting (QS) at 4.2 K were estimated to be 0.5380(60) mm/s and 0.268(10) mm/s, respectively. These values are almost consistent with the previous report [13]. The spectra contained the signals attributed to the impurity phases of hexagonal FeSe and tiny amounts of iron oxides. The spectrum at 4.2 K was fitted by the paramagnetic doublet and three small magnetic sextets with hyperfine fields ($H_{hf}$) of 264.7(80), 473.4(50) and 508.5(37) kOe as indicated by green, orange and blue fitting curves, respectively. The magnetic sextet fitted with $H_{hf} = 264.7(80)$ kOe corresponds to...
the signal of the minor-phase hexagonal FeSe [11]. The other two tiny magnetic sextets fitted with $H_{hf} = 473.4(50)$ or $508.5(37)$ kOe probably correspond to the signals of the Fe oxides with Fe$^{3+}$ in high-spin states. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Fig. 2 shows the $^{57}$Fe Mössbauer spectra of Fe$_{1.08}$Te at room temperature, 77 and 4.2 K. The spectrum at room temperature was analyzed by two types of doublets which are attributed to the two Fe sites. One site is the Fe in the FeTe layer (Fe-1 site), and the other is Fe which exists at the interlayer site (Fe-2 site). At 4.2 K, the clear magnetic sextet corresponding to the magnetic ordering around 70 K was observed.

4. Conclusion

We carried out the $^{57}$Fe Mössbauer measurements for FeSe and Fe$_{1.08}$Te. The single paramagnetic doublet was observed at whole temperatures for the superconducting FeSe phase. For Fe$_{1.08}$Te, the clear magnetic sextet was observed at 4.2 K, which was consistent with the antiferromagnetic ordering of Fe in the low-spin state associated with the structural change at 70 K.

Acknowledgement

This work was partly supported by a Grand-in-Aid for Scientific Research (KAKENHI).

References