μSR study of $FeSe_{1-x}S_x$ around nematic critical point

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Iron-based superconductors (FeSCs) provide an intriguing platform where the spin and orbital degree of freedom can contribute to the emergence of exotic phenomena including high temperature superconductivity. Superconductivity was usually observed in most FeSCs when antiferromagnetism in the parent materials was suppressed by chemical doping, indicating the competition between superconductivity and antiferromagnetism.[1)] On the other hand, another electronic state called electronic nematicity was clarified where the lattice C_4 symmetry is spontaneously broken by some electronic origin.[2)] The relation between superconductivity and electronic nematicity is one of key piece to understand the complex phase diagram. The recent nonmagnetic nematic states in FeSe may provide an opportunity to clarify this key piece. By sulfur doping on the selenium site, electronic nematicity was suppressed and superconductivity tended to be enhanced around the nematic critical point.[3)] This may indicate a competitive relationship between superconductivity and electronic nematicity, whereas the magnetic phase diagram is still controversial in the $FeSe_{1-x}S_x$ system. In this report, we studied the magnetic phase diagram of $FeSe_{1-x}S_x$ ($0.09 \leq x \leq 0.15$) from the view of electrical transport and muon spin relaxation.

From electrical transports, the electronic phase diagram of $FeSe_{1-x}S_x$ was still unclear below the superconducting transition temperatures. Figure 1(b)–(d) shows the temperature dependence of the electrical resistivity in $FeSe_{1-x}S_x$ single crystals under various magnetic fields (Bs). At zero magnetic fields, the resistivity curves showed a kink due to the tetragonal to the orthorhombic structural transition at temperature ranges from 30–60 K in the present sulfur doping range. At low temperatures, superconducting transitions were observed at around 10 K. Both the superconducting transition temperature (T_c) and the structural transition temperature (T_s) were summarized in Fig. 1(a). By sulfur doping, T_s continuously decreased and disappeared around $x = 0.16$ together with the broad maximum of T_c around 0.125. Since the electronic nematic phase were previously clarified below $x = 0.15$ in the orthorhombic phase, the normal state resistivity curves unveiled by high magnetic fields would provide further information about the relationship between superconductivity and electronic nematicity. Under the magnetic fields, the resistivity curves showed a suppression

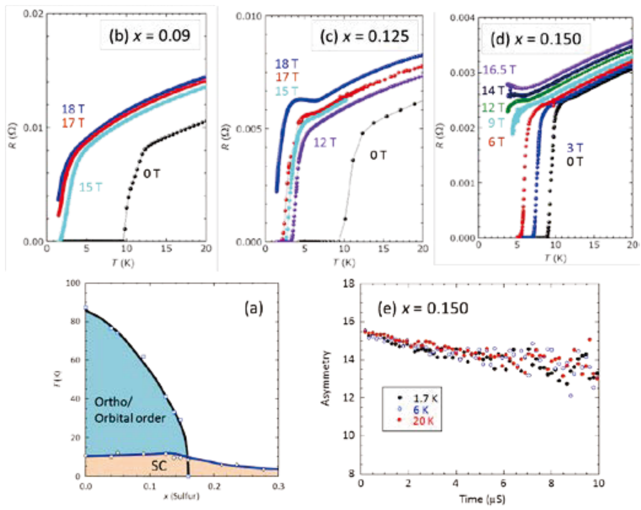

Fig. 1. (a) Electrical phase diagram of $FeSe_{1-x}S_x$. (b)–(d) Electrical resistivity curves for $x = 0.09 - 0.15$ under various magnetic fields. (e) μSR time spectra for $x = 0.15$ from 1.7 K to 20 K.

of T_c with an increase in B. For $x = 0.125 - 0.15$, other kink structures tended to be developed around 5 K, which resemble resistivity curves for the pressure induced antiferromagnetic transition in FeSe.[4)] To clarify the hidden magnetic phase below T_c, we carried out the zero field (ZF) μSR measurements in $FeSe_{1-x}S_x$ as shown in Fig. 1(e). ZF-μSR showed the relatively exponential-like time spectra from 1.7 K to 20 K, being similar with those of the FeSe single crystal. All spectra considerably overlapped. These demonstrated no development of magnetism where anomalies were detected in the resistivity curves under high magnetic fields.

For $x = 0.125$–0.15, resistivity anomalies under high magnetic fields suggested a development of another new phase at low temperatures whereas no development of magnetism was detected by the ZF-μSR measurements. An origin of resistivity anomaly is still unclear in the present states. Since the nonmagnetic nematic quantum critical point (QCP) would be a key to understand the mechanism of the superconductivity from the comparison to the magnetic QCP, further studies clarifying an origin of low temperature anomalies in resistivity curves may be important to understand the relationship between superconductivity, magnetism and electronic nematicity.

References

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