Doping Effect on Transport Properties of Layered Oxysulfide $Sr_2Cu_2CoO_2S_2$ with CoO_2 square planes

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Abstract

Layered cobalt oxysulfide $Sr_2Cu_2CoO_2S_2$ crystallizes in an unusual intergrowth structure which represents a combination of $SrCu_2S_2$ and $SrCoO_2$. $Sr_2Cu_2CoO_2S_2$ is a *p*-type antiferromagnetic semiconductor with T_N(=200K). And below T_t(=125K), the antiferromagnetic nature is changed from 2D to 3D. We studied Seebeck coefficient of $Sr_2Cu_2CoO_2S_2$ and its Cu-doped compounds. Their Seebeck coefficients near T_t tend to enhance by the Cu-doping into CoO_2 square planes. The curves of the temperature dependence of $Sr_2Cu_2Cu_xCo_{1-x}O_2S_2$ is changed near T_N, and the change points shift to high temperature by Cu-doping. The behavior resembles in T_N shift of the magnetic property. The transport properties of Cu-doped $Sr_2Cu_2CoO_2S_2$ is affected by their magnetism.

Key words: $Sr_2Cu_2CoO_2S_2$; Seebeck coefficient ; oxysulfide ;

Layered cobalt oxysulfide $Sr_2Cu_2CoO_2S_2$ [1] crystallizes in an unusual intergrowth structure (space group I/4mmm) [1,2] which represents a combination of transition-metal (TM) oxide and sulfide layers, as shown in Fig.1. The $SrCu_2S_2$ unit is of $ThCr_2Si_2$ type and the $SrCoO_2$ unit is isostructural to the infinite layer high-T_C cuprate $Sr_{0.15}Ca_{0.85}CuO_2$.

$Sr_2Cu_2CoO_2S_2$ is a *p*-type antiferromagnetic semiconductor with T_N(=200K) determined by magnetic susceptibility (χ) measurement and neutron powder diffraction (NPD) [3] using the high efficiency and high resolution measurements (HERMES [4]). Above T_t(=125K), the χ shows a broad maximum indicative of two-dimensional (2D) antiferromagnetic nature as normally seen for antiferromagnetic K_2NiF_4-type compounds. [3] X-ray photoemission spectroscopy (XPS) study have revealed that the Cu ion in the Cu_2S_2 layer is mono-valent state (Cu^+; d^{10}, S=0) and the Co ion in the CoO_2 square-planes is the strongly correlated electronic nature [3]. Therefore, the magnetic nature is not originated from the $(Cu^+S)_2$ layers but the strongly correlated $Co^{2+}O_2$ square-planes. In this paper, we report the transport properties of Cu-doped $Sr_2Cu_2CoO_2S_2$.

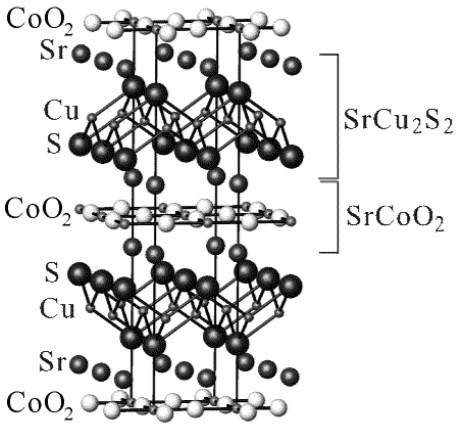

Fig. 1. Crystal structure of $Sr_2Cu_2CoO_2S_2$.

We measured Seebeck coefficient(S) through Cu

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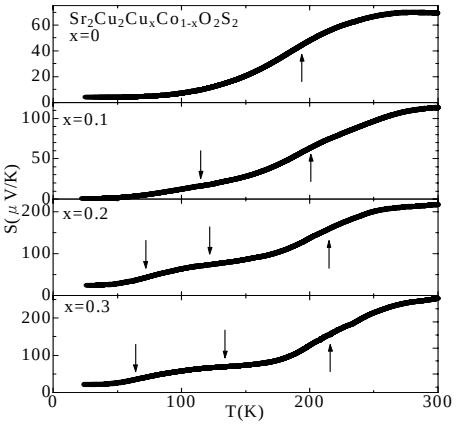

Fig. 2. Temperature dependence of Seebeck coefficient for $Sr_2Cu_2Cu_xCo_{1-x}O_2S_2$.

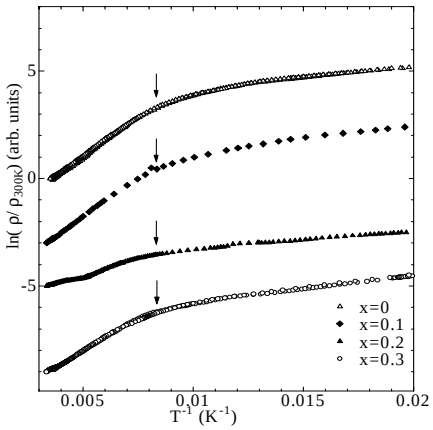

Fig. 3. Temperature dependence of electric resistivities for $Sr_2Cu_2Cu_xCo_{1-x}O_2S_2$.

wires which were attached Ag-paste. The temperature difference $\Delta T < 0.02T$ across the sample was measured by two Au-0.07Fe thermocouples. The measured sample was the carefully prepared polycrystalline pellet [5].

Fig. 2 shows the Seebeck coefficient of Cu-doped $Sr_2Cu_2CoO_2S_2$ depending on temperature. The arrow symbols are inflection points ($d^2S/dT^2 = 0$). Seebeck coeffcient of $Sr_2Cu_2Cu_xCo_{1-x}O_2S_2$ is over 0 on all measured temperature, so that we confirm that this compound is p-type semiconductor. The absolute value of S is increase gradually with x in $Sr_2Cu_2Cu_xCo_{1-x}O_2S_2$.

$Sr_2Cu_2CoO_2S_2$ (x=0) has a inflect point near T_N. T_N was determined by $d(\chi T)/dT$ which is proportional to the heat capacity [6,7]. In addtion, antiferromagnetic NPD peaks originated from the CoO_2 planes disappear above the tempareture T_N [3]. The inflect points near T_N are also the Cu-doped $Sr_2Cu_2CoO_2S_2$, and gradually increases with x. This feature of the inflect points depending on x is similar to T_N dependence on x.

The Seebeck coefficients tend to enhance by the Cu-doping into CoO_2 square planes at 110K. Near this temperature, the magnetic properties are changed 2D-3D antiferromagnetic coupling at T_t (x=0) [3], and the unusual spin-frustrated system below 80K [6]. These electric resistivities also have anomaly near 125K(fig.3).

These changes caused by Cu-doping indicates that not only carrier increase, but also the system affected the magnetic ordering or the strongly correlation between carriers.

In summary, we has been measured Seebeck coefficients of the layered antiferromagnet $Sr_2Cu_2CoO_2S_2$. The Seebeck coefficients near T_t tend to enhance by the Cu-doping into CoO_2 square planes. The curves of the temperature dependence of $Sr_2Cu_2Cu_xCo_{1-x}O_2S_2$ is changed near T_N, and the change points shift to high temperature by Cu-doping. This behavior resembles in T_N shift of the magnetic property. The transport properties of Cu-doped $Sr_2Cu_2CoO_2S_2$ is affected by the strongly correlation between carriers.

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