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Physical properties of $Ba_2MnZn_2As_2O_2$

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Abstract

We have measured the specific heat, electrical resistivity, and magnetic susceptibility of $Ba_2MnZn_2As_2O_2$. This phase has a magnetic transition at 30 K, and zero-field-cooled and field-cooled magnetic susceptibilities separate below this transition. The specific heat has a γT term suggesting a spin-glass-like state. The electrical resistivity is semiconducting with an activation energy of 1070 K, which rapidly decreases at the rate of -106 K/GPa.

Keywords: Electrical resistivity; Magnetic susceptibility; Mn pnictide oxide; Specific heat

1. Introduction

A series of layered Mn pnictide oxide compounds, $A_2Mn_3Pn_2O_2$ ($A = Sr,Ba$; $Pn = P, As, Sb, Bi$) have been recently synthesized and their interesting magnetic properies have been revealed [1]. These compounds crystallize in the $Sr_2Mn_3As_2O_2$ structure type (I4/mmm) in which $Mn_2Pn_2^{2-}$ layers and MnO_2^{2-} layers are alternatively stacked along *c*-axis separated by alkaline earth cations [1]. The $Mn_2Pn_2^{2-}$ layers are isostructural to those in $ThCr_2Si_2$ structure type and the MnO_2^{2-} layers are similar to the CuO_2 planes in high-T_c superconductors. Recently, Ozawa et al. [2] succeeded in synthesizing a new compound in which Zn atoms are substituted for the Mn atoms in $Mn_2As_2^{2-}$ layers; $Zn_2As_2^{2-}$ layers and MnO_2^{2-} layers are stacked in this new compound. In this paper we will report the interesting physical properties of this new compound.

The sample was synthesized by heating a pressed pellet of BaO, Mn, Zn, As (2 : 1 : 2 : 2). Details were described elsewhere [2]. The final product was characterized by X-ray diffraction showing no other phase present. The magnetic susceptibility was measured using SQUID magnetometer (Quantum Design Co.). Specific heat was measured with a quasi-adiabatic method. Electrical resistivity was measured with a conventional four-probe method under pressures. The pressure was applied up to 2 GPa using a piston-cylinder-type pressure cell.

2. Results and discussion

Fig. 1 shows the temperature dependence of inverse magnetic susceptibility measured at 300 G. The susceptibility χ above 140 K can be well fitted with the Curie–Weiss law, $\chi = C/(T-\theta)$ where C and θ are constant parameters. The effective magnetic moment and the value of θ were $5.9\mu_B$ and -41 K, respectively. The value of effective magnetic moment is close to that of $S = 5/2$ ($5.91\mu_B$) high spin state of Mn^{2+}. The value of magnetic susceptibility gradually deviates from the Curie–Weiss law below 140 K. Ozawa et al. attributed this behavior to the two dimensionality of this compound and showed that it can be fitted with the 2D Heisenberg model [3]. At 30 K a magnetic transition occurs. Below this transition the values of zero-field-cooled (ZFC) magnetic susceptibility and field-cooled (FC) one are different. Spin-glass state has been proposed to explain this behavior [2].

Fig. 2 shows the temperature dependence of specific heat as C/T versus T^2 plot which was well described with an expression $C = \gamma T + \beta T^3$ where γ and β are constant

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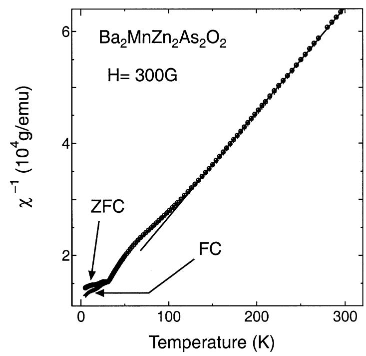

Fig. 1. Inverse magnetic susceptibility as a function of temperature.

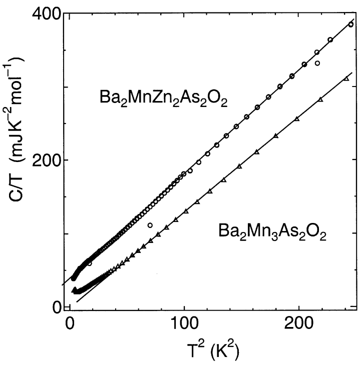

Fig. 2. Specific heat as C/T versus T^2 plot. The data of $Ba_2Mn_3As_2O_2$ are also plotted.

parameters and the values were 38.7 and 1.414 $mJmol^{-1}\ K^{-4}$, respectively. Supposing the βT^3 term is a lattice contribution, the Debye temperature estimated from the β value was 111 K. As described later $Ba_2MnZn_2As_2O_2$ is a semiconductor with an energy gap. Consequently the origin of the γT term is not the same as that observed in metals and is probably related to the spin-glass-like behavior of magnetic susceptibility

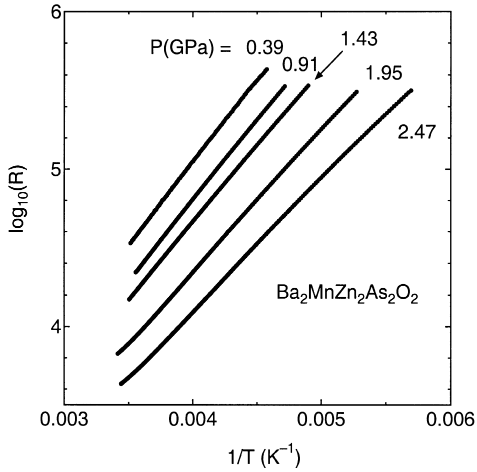

Fig. 3. Pressure dependence of electrical resistivity.

below 30 K. It is noted that the γT term was not observed in $Ba_2Mn_3As_2O_2$ as shown in Fig. 2. In $Ba_2Mn_3As_2O_2$ the spin-glass-like magnetic transition was not observed either [1]. Thus the γT term and the spin-glass-like magnetic transition are closely related.

In Fig. 3 the electrical resistivity under pressures is displayed in log(R) versus $1/T$ plot. The electrical resistivity is semiconducting and the activation energy T_0 in the expression $A\exp(-T_0/T)$ is 1070 K at ambient pressure. The value of T_0 rapidly decreases with increasing pressure at the rate of -106 K/GPa. The cause of this large pressure coefficient is not clear so far.

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