MAGNETIC PROPERTY OF SmAg1-xInx

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MAGNETIC PROPERTY OF $SmAg_{1-x}In_x$

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Abstract. – Magnetic measurements have been performed on $SmAg_{1-x}In_x$ with CsCl type structure. It is antiferromagnetic for $x < 0.1$ and ferromagnetic for $0.2 < x < 0.7$. A very large coercive force, larger than 10 T, was found for $x > 0.3$ at 4.2 K. The ferromagnetic moment is about 0.07 μ_B. The crystal field analysis revealed that the ground state is Γ_7.

The relatively low lying excited state with $J = 7/2$ about 1 700 K above the ground state with $J = 5/2$ must be taken into account to consider the physical property of Sm. For the compound of SmZn with CsCl type structure [1], a very strong polarization of conduction electrons was confirmed by neutron diffraction to be antiparallel to the 4f moment and larger than the 4f moment in magnitude. In this system of $SmAg_{1-x}In_x$, the effective number of the conduction electrons can be changed by substituting Ag by In or changing x. It is our interest to investigate the x dependence of the magnetic and conduction properties of $SmAg_{1-x}In_x$.

Samples were prepared by plasma-jet melting of Sm metal with 4N purity and Ag and In metals with 5N purity followed by annealing in a vacuum as the same method as expressed by Yagasaki *et al.* [2]. The magnetic measurements were done by using a Faraday type magnetic balance at 2.4 kOe, a Hartshorn bridge circuit at a few Oe and a vibrating sample magnetometer up to 15 T.

The crystal structure was found to be CsCl type for $0 < x < 0.7$ by X ray diffraction at room temperature. The lattice constant is 3.69 A for $x = 0$ and 3.80 A for $x = 0.7$, which increases with increasing x.

Figure 1 shows a magnetization curve of a compound with $x = 0.4$ measured at 6 K, as an example of high field magnetic measurements. A critical field appears at $H = 12.5$ T in the initial curve and the magnetization does not saturate even at $H = 15$ T yet. It exhibits a very large magnetic hysteresis loop: the coercive force is 9.0 T and the center of the loop shifts toward negative field direction by 0.5 T. It should be noted that the critical field of the initial curve is much higher than the coercive force. All the compounds for $x > 0.3$ have the same big hysteresis loop at low temperatures. The compounds for $x < 0.2$ have almost no hysteresis, and the magnetization curve is straight for $x < 0.1$, but behaves a little ferromagnetically for $x = 0.2$. Figure 2 shows temperature dependences of the coercive force H_c and the remanent magnetization σ_r. The coercive force increases rapidly with decreasing temperature and it exceed 10 T at 4.2 K. As the magnetization does not saturate at our experimental maximum field of $H = 15$ T, σ_r decreases with decreasing temperature at $T < 14$ K. The value of σ_r is very small: the extrapolated value of σ_r from $T > 14$ K to 0 K is about 0.07 μ_B per unit cell. It should be noted that, at temperatures higher than 14 K, H_c is proportional to 4.0 th power of σ_r. To know the origin of such a large coercivity, we need to check the elastic property of the sample.

The temperature dependence of dc susceptibility measured at 2.4 kOe is shown in figure 3. These temperature dependence of the susceptibility looks like as $NdAg_{1-x}In_x$. [2] All the compounds have two peaks:

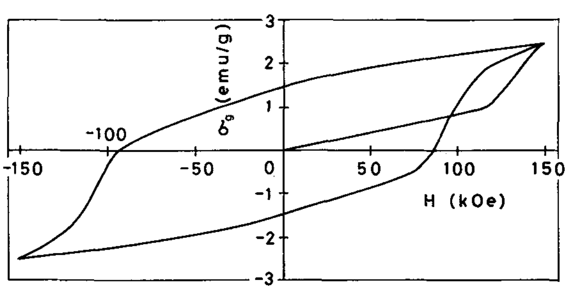

Fig. 1. – The magnetization curve for $SmAg_{0.6}In_{0.4}$ measured at 6 K.

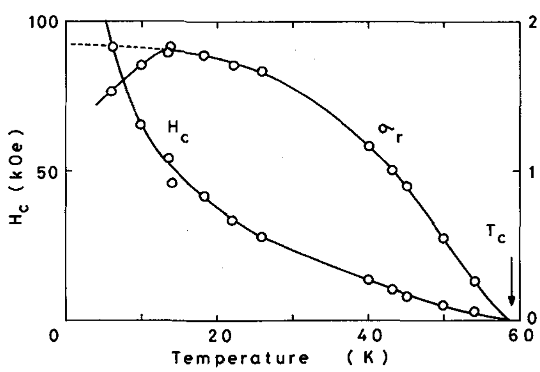

Fig. 2. – Temperature dependence of the coercive force H_c and remanent magnetization σ_r for $SmAg_{0.6}In_{0.4}$.

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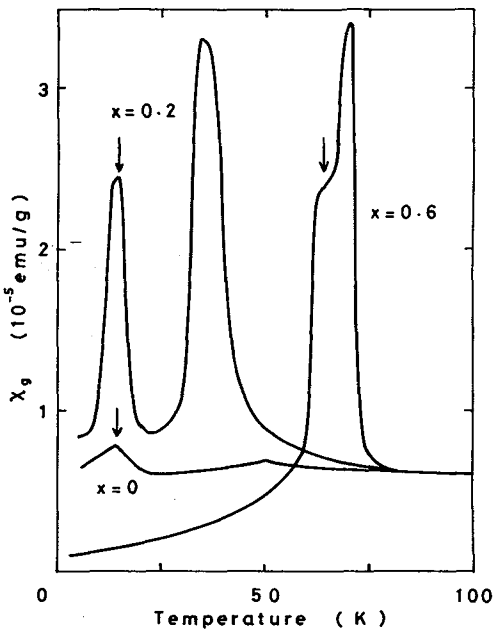

Fig. 3. – Temperature dependence of the dc susceptibility measured at $H = 2.4$ kOe for $x = 0$, 0.2 and 0.6. T_M is indicated by an arrow for each specimen.

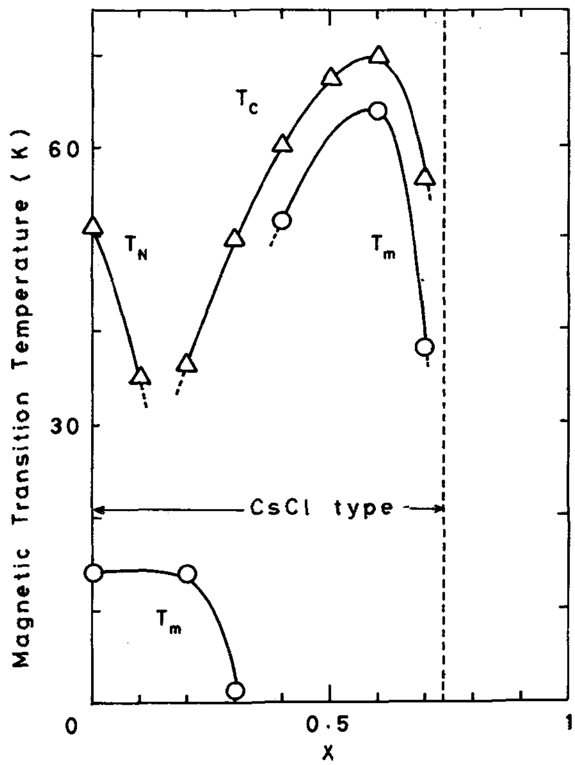

Fig. 4. – The magnetic phase diagram for $SmAg_{1-x}In_x$.

the higher temperature side one corresponds to T_N or T_C and the temperature of the lower side one is denoted as T_M. As no anomaly was observed at T_M in the resistivity [3], the origin for the peak at T_M is not clear at the present stage; T_M might exhibit the magnetic order-order transition as appeared in NdZn [4] and DyAg [5] or it might be due to some other effects. Figure 4 shows the magnetic phase diagram deduced from the results of the magnetization and susceptibility measurements. The compounds for $x < 0.1$ are antiferromagnetic. It was very subtle to determine whether the compound with $x = 0.2$ is ferromagnetic or antiferromagnetic. The compounds for $x > 0.3$ are ferromagnetic. The x dependence of T_N and T_C of this system looks like very much as $GdAg_{1-x}In_x$ [6].

The paramagnetic susceptibility does not obey the Curie-Weiss law. As a result of the crystal field calculation including $J = 5/2$ and $7/2$ multiplets, it was concluded that the ground state is Γ_7 (positive forth-order CEF parameter) with the magnetic moment of 0.24 μ_B at 0 K and the first excited Γ_8 state is 480 K above the ground state. The positive forth-order CEF term is inconsistent with other CsCl-type RE compounds as discussed in [1]. The value of ferromagnetic spontaneous moment of 0.07 μ_B is very small compared with the ground-state moment, but coincides with that of SmZn [1]. We need more investigation to obtain information about 4f moment and conduction band polarization.

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