Magnetic properties and magnetocaloric effect of $ErAl_{2-x}B_x$

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To study the effect of B substitution on the magnetism and magnetocaloric effect in $ErAl_2$, the X-ray diffraction and magnetization were measured. Though the crystal structure was maintained as cubic $MgCu_2$-type $ErAl_2$ with B addition, the lattice parameter remained unchanged. The Curie temperature of $ErAl_{2-x}B_x$ also did not change. These results suggest that Al in $ErAl_2$ was barely substituted by B. The values of magnetization and magnetic entropy change for $ErAl_{2-x}B_x$ were significantly decreased compared to those for $ErAl_2$. These results imply that the crystalline electric field scheme of $ErAl_2$ may be change.

Keywords: Magnetocaloric effect; $ErAl_{2-x}B_x$;

1. Introduction

Recently, magnetic refrigeration is attracting attention because of high efficiency and environmental friendliness. Especially, magnetic refrigeration is being considered for hydrogen liquefaction. Magnetic refrigeration is a cooling method using magnetocaloric materials and magnetic field. Magnetocaloric materials are expected to have a large magnetic entropy change (ΔS_m) and exhibit magnetic order at between 20 and 80 K. $ErAl_2$, crystallizes in the cubic $MgCu_2$-type structure, shows a large ΔS_m of 35 J/K kg accompanied with a ferromagnetic ordering at the Curie temperature (T_C) of 14 K [1]. However, since ΔS_m decreased above 20 K, T_C must be increased. It is reported that T_C of $ErAl_2$ increase applying pressure [2]. Therefore, by replacing Al for B, the lattice constant decreases, resulting in that T_C would be increased. In this study, B addition effect on magnetic properties of $ErAl_2$ were investigated.

2. Results and discussion

Figure 1 shows the X-ray diffraction (XRD) patterns of $ErAl_{2-x}B_x$ (x=0.05 and 0.2). Most peaks can be indexed as cubic $MgCu_2$-type structure. The secondary phase is identified as the Er_2O_3. The volume fraction of $ErAl_2$ phase is 95%, indicating that the effect of the secondary phase on the magnetic properties is small. The positions of diffraction peaks changed little with increasing B content. The lattice constant estimated by the least-square method also did not change with B addition. These results indicate that Al in $ErAl_2$ was not substituted by B.

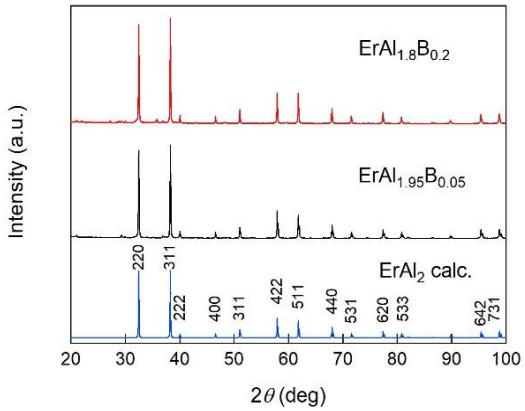

Figure 1: XRD patterns of $ErAl_{2-x}B_x$ (x=0.05 and 0.2.).

Magnetization as a function of temperature showed a sudden increase below 20 K, indicating that ferromagnetism is maintained even when B is added. T_C is 15 K for x=0.2, which is little changed from 14 K for x=0. The value of saturation magnetization of x=0.2 at 5 K is 160 emu/g compared to ~220 emu/g of $ErAl_2$ [1].

The values of ΔS_m are calculated from the data of the isothermal magnetization using the Maxwell relationship. Figure 2 presents the ΔS_m of $ErAl_{2-x}B_x$ with a magnetic field change of 5 T versus temperature. ΔS_m peaked at approximately T_C. The maximum value of $|\Delta S_m|$ is 25.5 J/K kg for x=0.2, which is more than 25% smaller than 35J/K kg of x=0.

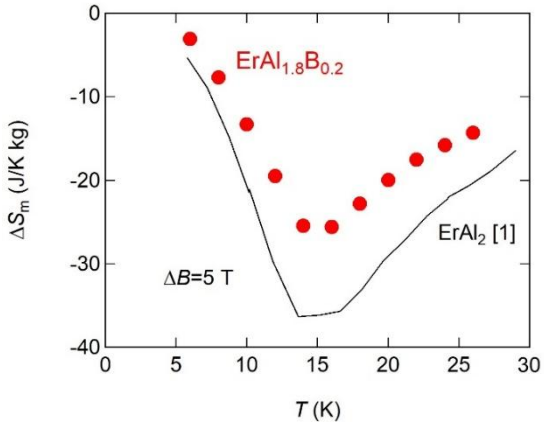

Figure 2: Magnetic entropy change of $ErAl_{2-x}B_x$ (x=0.2) with x=0 [1].

Despite the small fraction of impurity phase, the values of ΔS_m were significantly decreased. One possibility is the change in the crystalline electric field scheme by B addition. The specific heat measurements are in progress to investigate the crystalline electric field splitting.

References

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