Nanoparticle Approach to the Formation of $Sm(Fe_{1-x}Co_x)_{11}Ti$ Particles

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Recently, thin films of $Sm(Fe_{1-x}Co_x)_{12}$ compounds ($0 \le x \le 0.3$) have been successfully synthesized [1] and they showed the excellent intrinsic hard magnetic properties, *i.e.*, M_s of 1.78 T, H_A of 12 T, and T_C of 859 K. On the other hand, to obtain the isolated particles of RFe_{12} compounds, we need a nonmagnetic stabilizer, *i.e.*, $R(Fe,M)_{12}$ (M: Ti, V, Cr, Mn, Mo, W, Al, or Si), for maintaining the $ThMn_{12}$ structure due to the thermodynamic instability. However, these stabilizers lead the decrease of a saturation magnetization by substituting with Fe sites. Element Ti can stabilize the $ThMn_{12}$ structure with the smallest amount among the above stabilizers [2]. On the other hand, a reduction diffusion (RD) process was found to be an effective synthesis method for $Sm_2Fe_{17}N_3$ particles [3,4] because this process can produce the equiaxed-shape particles with the lower temperature than metal melting method. In this study, we focus on the synthesis of a single-phase $Sm(Fe_{1-x}Co_x)_{11}Ti$ ($0 \le x \le 0.3$) particles and the investigation on the magnetic properties depending on the RD times. First, the mixture of Sm acetate, Fe acetate, Co acetate, and Ti isopropoxide was chemically reacted in organic solvents to obtain the metal-oxides nanoparticles (NPs). Then, these NPs were calcined to remove organic ligands and the H_2 reduction and RD process with Ca metal were conducted to reduce the metal ions. Finally, the products were washed with N_2-purged mQH_2O to remove CaO and the remaining Ca metal.

Figure 1 shows the XRD patterns of $Sm(Fe_{1-x}Co_x)_{11}Ti$ particles with different RD times at 1223 K. Nearly single-phase $Sm(Fe_{1-x}Co_x)_{11}Ti$ with <1wt% impurities ($(Fe-Co)_2Ti$ and/or Fe-Co) was produced by the RD process for 1/6-1 h. On the other hands, the RD process for 2 h gave a larger amount of impurity assigned at around 44.8 ° due to the evaporation of Sm, as seen in Fig.1. Figure 2 shows the SEM images and the coercivities of $Sm(Fe_{1-x}Co_x)_{11}Ti$ particles depending on the RD times. The H_c increased with decreasing the RD time because both growth and fusion of particles were suppressed to maintain the equiaxed-shape of particle, as seen in SEM images of Fig. 2 (SEM images).

Reference

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2) K H J Buschow, Report on Progress in Physics, **54** (1991) 1123
3) S. Okada *et al.*, AIP ADVANCES **7** (2017) 056219
4) J. Kim *et al.*, Chemistry Letters, in press.

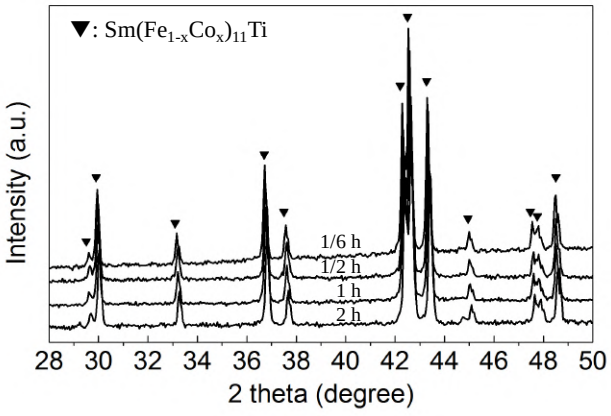

Fig. 1 XRD patterns of $Sm(Fe_{1-x}Co_x)_{11}Ti$ particles depending on RD times (1/6, 1/2, 1, and 2 h) at 1233 K.

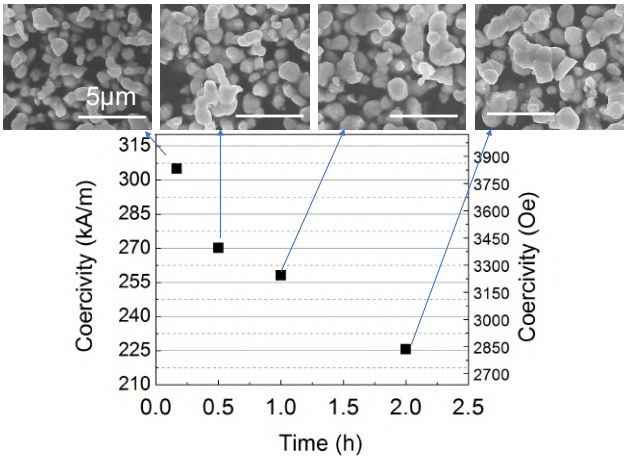

Fig. 2 SEM images (upper) and coercivities (down) of $Sm(Fe_{1-x}Co_x)_{11}Ti$ particles depending on RD times at 1233 K.