PROPOSAL OF GRAIN BOUNDARY OXIDES FOR HIGH K_u $Co_{80}Pt_{20}$ GRANULAR MEDIA WITH SMALL GRAIN SIZE

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I. INTRODUCTION

CoPt-oxide granular media with columnar grain growth have been widely used for perpendicular magnetic recording. To further increase the recording density of the media, enhancement of magnetocrystaline anisotropy (K_u) and reduction of magnetic grain diameter (*GD*) are required. In the previous study, it was found that a granular medium with high K_u can be obtained when oxide with low melting point (T_m), especially B_2O_3, was utilized due to the promotion of columnar grain growth[1)]. However, the effect of T_m of the oxide on the *GD* is still unclear. Therefore, in this report, after examining the influence of various grain boundary oxides on *GD*, we will discuss about the guiding principle of choosing grain boundary oxide materials.

II. RESULTS AND DISCUSSION

Figure 1 show dependence of (a) magnetocrystalline anisotropy (K_u) and (b) grain diameter (*GD*) for $Co_{80}Pt_{20}$ −30vol% single oxide granular media with d_{mag} of 16 nm on melting point (T_m) of the grain boundary oxides materials. The inset shows the definition of *GD*, which is evaluated from CoPt (11.0) diffraction from the XRD in-plane profiles by Scherrer's equation[2,3)]. Here, from the result of out-of-plane XRD profiles for the granular media with grain boundary oxide materials with various T_m (the result are not shown here), these granular structure magnetic grains are considered to have *c*-plane sheet texture orientation. When T_m of oxide increases from 450 to 2410℃, K_u and *GD* decrease from 7.7 to 4.1×10^6 erg/cm^3 and from 5.6 to 3.0 nm, respectively. From this result, it suggests that a granular medium with both high K_u and low *GD* cannot be realized by only employing single oxides.

We consider that a granular medium with reasonably high K_u and small *GD* may be achievable by utilizing double grain boundary oxides with moderate T_m which consist of high and low T_m oxides. To verify the effect of double oxides, second oxides with T_m ranging from 450 to 2330℃ and first oxide of low T_m (B_2O_3) were added to $Co_{80}Pt_{20}$ alloy ($Co_{80}Pt_{20}$-15vol% B_2O_3-15vol% second oxides). Figure 2 shows dependence of K_u and *GD* on T_m of various second oxides. When T_m of the second oxide is lower than 1857℃ (TiO_2), K_u is almost comparable with that of B_2O_3. For T_m higher than 1857℃, K_u decreases. In the case of *GD*, it is almost constant for T_m of the second oxide lower than 1723℃ (SiO_2). When T_m is higher than 1723℃, *GD* decreases. From this result, the addition of TiO_2 for the second oxide is effective to realize a granular medium with high K_u and small *GD*.

Figure 3 shows in-plane-view TEM of $Co_{80}Pt_{20}$-15vol% B_2O_3-15vol% typical second oxide (second oxide: (i) B_2O_3 (T_m: 450℃), (ii) SiO_2 (T_m: 1723℃), (iii) TiO_2 (T_m: 1857℃) and (iv) Cr_2O_3 (T_m: 2330℃)). Observing the detailed in-plane-view TEM of high T_m second oxides such as TiO_2 and Cr_2O_3, grain boundaries with different thicknesses are confirmed. The thick grain boundaries are similar to that of the second oxide of B_2O_3. Inside some magnetic grains thin grain boundaries can also be observed. It is considered that the existence of the thin grain boundaries induces the *GD* reduction. Generally, the variation of the grain boundary thickness will lead to a wide grain size distribution. The application of underlayer with smaller grains size than current one may be effective to obtain a granular medium with homogeneous grain size.

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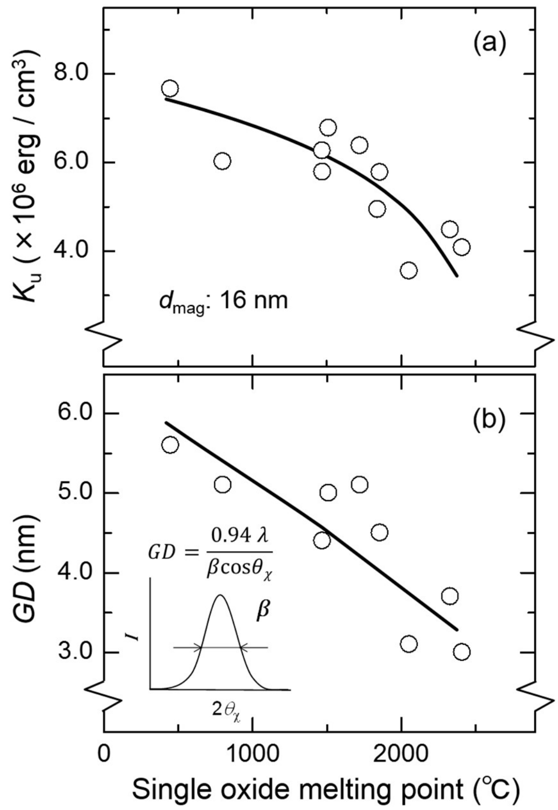

Fig. 1. Dependence of (a) magnetocrystalline anisotropy (K_u) and (b) grain diameter (*GD*) for $Co_{80}Pt_{20}$–30vol% single oxide granular media with d_{mag} of 16 nm on melting point (T_m) of the grain boundary oxides materials. The inset shows the definition of *GD*, which is evaluated from CoPt (11.0) diffraction from the XRD in-plane profiles by Scherrer's equation[2,3].

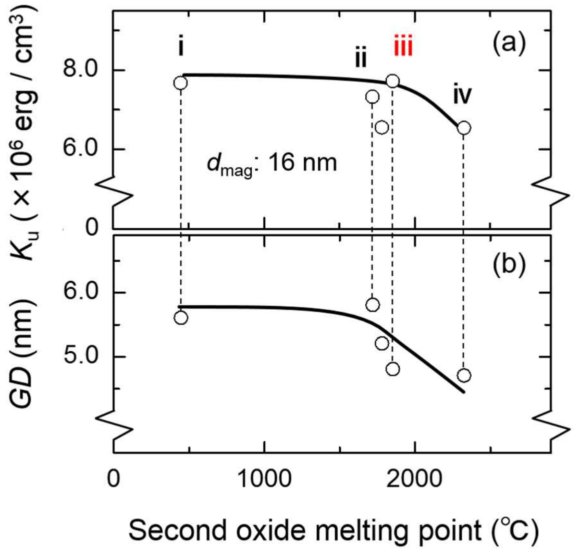

Fig. 2. Dependence of (a) K_u and (b) *GD* of various oxides in $Co_{80}Pt_{20}$-15vol% B_2O_3-15vol% second oxide granular media with d_{mag} of 16 nm on T_m of the grain boundary oxides materials. In-plane-view TEM of these samples (second oxide: (i) B_2O_3 (T_m: 450℃), (ii) SiO_2 (T_m: 1723℃), (iii) TiO_2 (T_m: 1857℃) and (iv) Cr_2O_3 (T_m: 2330℃)) are shown in Figure 3.

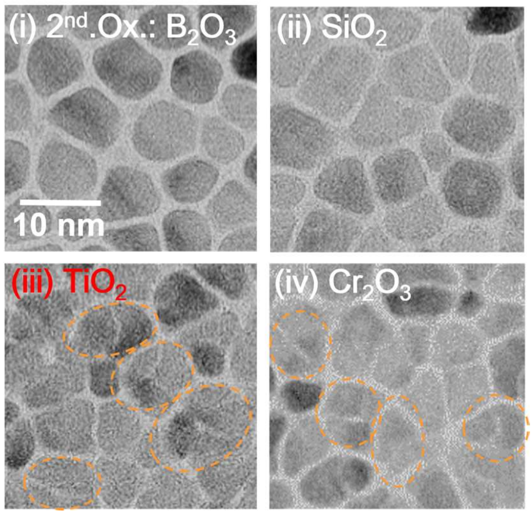

Fig.3 In-plane-view TEM of granular media shown in Figure 2.