Distribution functions of two-dimensionally oriented magnetic particles

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Introduction

Particle orientation is important in the recording media and permanent magnets. Generally, the orientation is simply studied by X-ray diffraction and the value of the magnetization remanence along the effective easy axis[1]. Furthermore, the magnetic anisotropy field (H_a) of the recording media has been recently studied using ferromagnetic resonance (FMR). To know the precise angular distribution of easy axis in an assemble composed of isolated single-domain particles, Shtrikman and Treves proposed a method to determine an axially-symmetry distribution function by the measurements of the angular dependence of the remanence[2]. We pointed two problems in the theory: one is that $f(\alpha)$ has negative value around 60° and the another is that $f(\alpha)$ has a small peak at 90°[3]. For two-dimensional distribution, a theory is proposed by El-Hilo et al.[4]. In this paper, we measure the angular dependence of the remanence ratio of particulate taps and discuss the two-dimensional distribution function.

Experimental

The angular dependence of remanence ratio $[I_p(\beta)/I_s]$ of commercial audio metal (α-Fe) and γ-Fe_2O_3 tapes and video metal and Co-γ-Fe_2O_3 tapes were measured in the tape plane. The remanence ratio is expressed by distribution function $[I_p(\beta)=(1/\pi)\int_{-\pi/2}^{\pi/2} I_s\cos\theta\, f(\alpha)d\theta]$. The distribution function $f(\alpha)$ was obtained by cosine function series $[f(\alpha)=A_0+\Sigma A_{2n}\cos(2n\alpha)]$ [4].

Results and Discussion

Figure 1 shows the magnetoremanence (I_p/I_s) of the magnetic particles of the audio tapes; the easy-axis orients tape length direction. The peak $f(\alpha)$ value of α-Fe tape is higher than that of γ-Fe_2O_3 tape as shown in Fig. 2. The value of $f(\alpha)$ decreases with angle. However, small peaks are observed at α=65°: small negative value around α=90° is observed for α-Fe [see Fig.2(a)]. This is similar to that of Sr ferrites analyzed by the Strickman-Treves three-dimensional model [3]. The most likely cause is that $f(\alpha)$ is expressed by the periodic function of cosine polynomial as same as the two-dimensional Legendre polynomial. Therefore, we use Gaussian function and the small peak vanishes as shown in Fig. 2(b).

To clarify the problem of the using a periodic function polynomial, we fitted for a rectangular distribution (full width=d, height=1/d) by cosine polynomial and Gauss function. And we found that the cosines polynomial is not suited for a sharp distribution (d≤40°): small peak appears at around 65°. For a broad distribution (d≥100°), an oscillation appears around 0°.

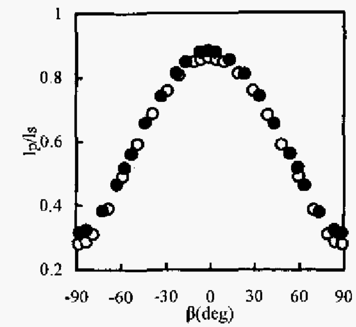

Fig. 1 Angular change in the magnetoremanece ratio (I_p/I_s) for α-Fe (closed) and γ-Fe_2O_3 (open) tapes.

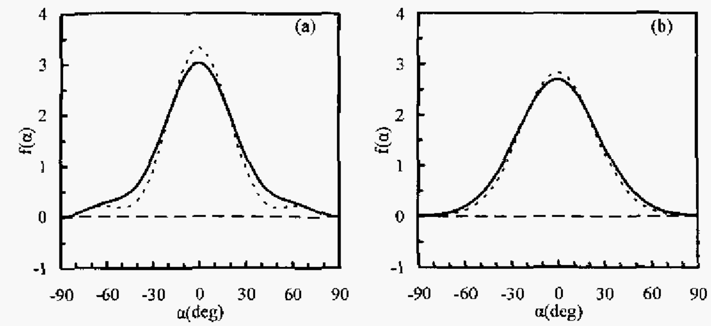

Fig. 2 Distribution function $f(\alpha)$ for audio α-Fe and γ-Fe_2O_3 tapes (α-Fe: solid; γ-Fe_2O_3: dashed). (a) $f(\alpha)$ by cosine function series, (b) $f(\alpha)$ Gauss function.

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