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Effects of sub-domain structure on initial magnetization curve and domain size distribution of stacked media

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ABSTRACT

In this paper, in order to confirm the sub-domain structure in stacked media demagnetized with in-plane field, initial magnetization curves and magnetic domain size distribution were investigated. Both experimental and simulation results showed that an initial magnetization curve for the medium demagnetized with in-plane field (MDI) initially rose faster than that for the medium demagnetized with perpendicular field (MDP). It is inferred that this is because the MDI has a larger number of domain walls than the MDP due to the existence of the sub-domains, resulting in an increase in the probability of domain wall motion. Dispersion of domain size for the MDI was larger than that for the MDP. This is because sub-domains are formed not only inside the domain but also at the domain boundary region, and they change the position of the domain boundary to affect the domain size.

1. Introduction

Signal quality has to be improved in order to achieve higher recording density of hard disks (HDs). In the current recording media, formation of magnetic domains is one of the causes of media noise components such as transition noise and track edge noise [1–3]. It has been discussed that the intergrain exchange coupling, recording layer thickness and interlayer exchange coupling in stacked media affect the domain structure [4–6], and decreasing magnetic domain size is effective to reduce the media noise [1]. Abarra et al. showed that the noise of demagnetized media was decreased by demagnetizing field in in-plane direction [7]. Besides, we have investigated the influence of applied field direction on magnetic domain structure of demagnetized stacked media with a magnetic force microscope (MFM) [8]. This study showed MFM output decreased although domain size did not change as the applied field direction leaned towards in-plane direction, from which we inferred that when magnetic field was applied in in-plane direction, magnetic domain included smaller reversed domain, namely sub-domain, in it, which was smaller than the MFM resolution limit of 25 nm. The sub-domain is schematically shown in Fig. 1. The sub-domain structure means that there are smaller reversal domains in ordinary domains. If the sub-domain is formed, it is thought that leakage field from domains is decreased although the averaged domain size estimated from MFM images does not change. Furthermore, Yamaguchi et al. used simulations to study the formation of sub-domains and discussed their origin [9].

It is assumed that formation of the sub-domain structure in the demagnetized state affects some macroscopic magnetic properties. Accordingly, in this paper, we investigated initial magnetization curves and magnetic domain size distribution of stacked medium to clarify the existence of the sub-domain by experiments and simulation in observable range.

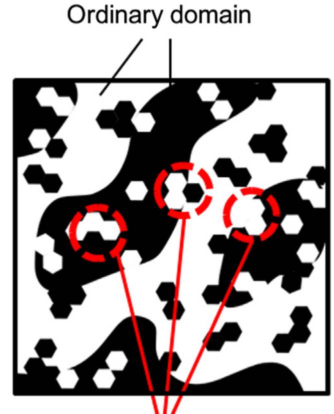

Fig. 1. Schematic of sub-domain structure.

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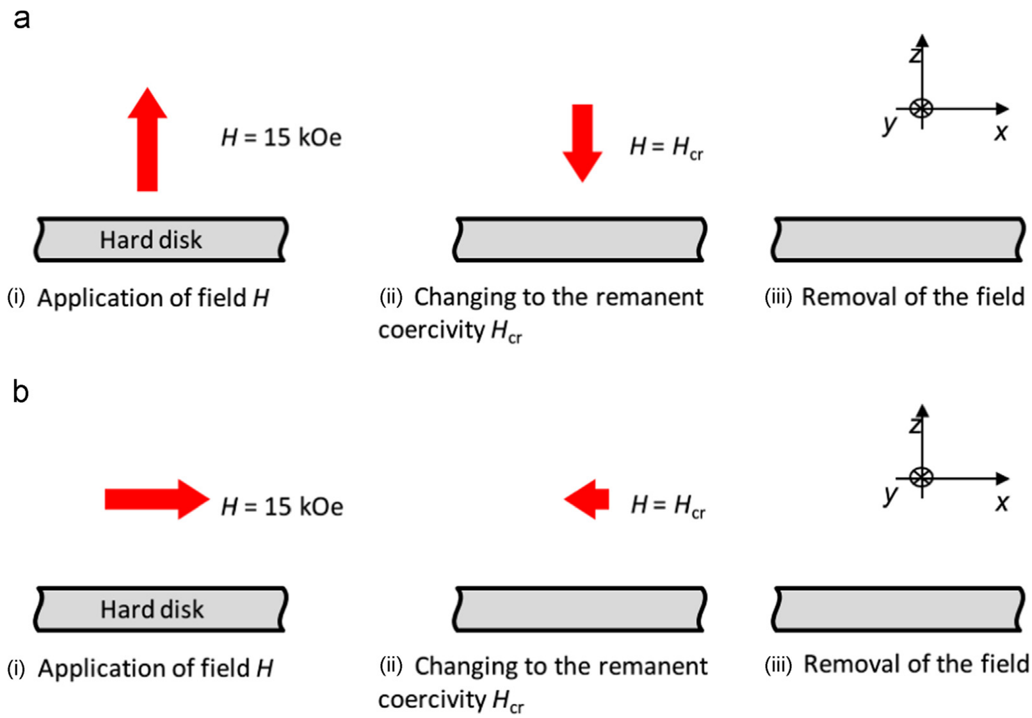
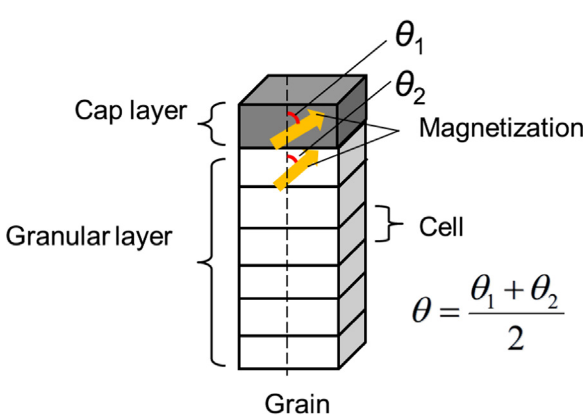


Fig. 2. Demagnetization method. (a) Perpendicular demagnetization. (b) In-plane demagnetization.



$$\theta = \frac{\theta_1 + \theta_2}{2}$$

Fig. 3. Relationship between magnetization of the cap layer and the granular layer and θ.

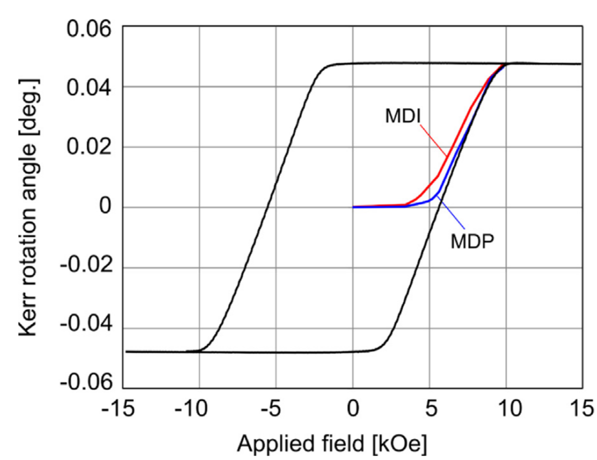


Fig. 5. Initial magnetization curves for the MDP and MDI obtained with Kerr observation.

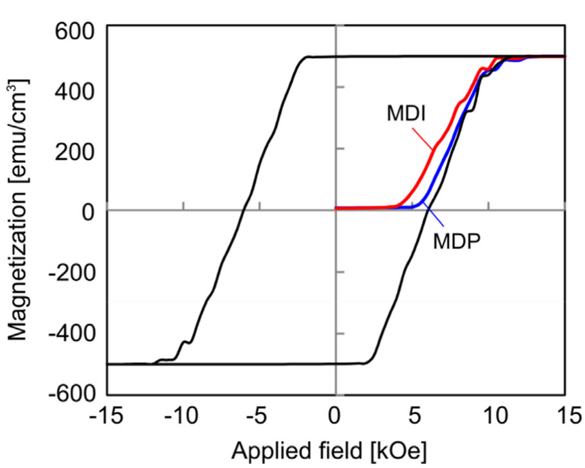


Fig. 4. Initial magnetization curves for the MDP and MDI obtained with micro-magnetic simulation.

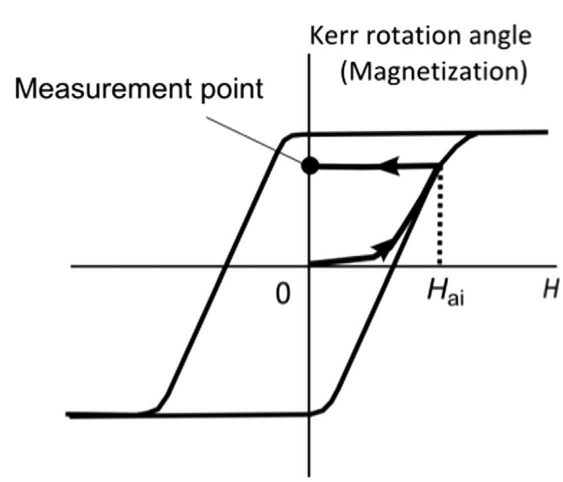


Fig. 6. Measurement point on a hysteresis loop.