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Co 박막에서 Barkhausen 효과의 자구동역학

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Domain Dynamics of Barkhausen Effect in Co Thin Films

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1. INTRODUCTION

It is recognized that the magnetization reverses with a sequence of discrete and jerky jumps, known as the Barkhausen effect. Recently, interest in the Barkhausen effect has grown as it is a good example of dynamical critical behavior, evidenced by experimental observation of a power law distribution of the Barkhausen jump size[1]. So far, most experimental studies have been carried out on bulk samples using a classical inductive technique, which is difficult to apply to thin film samples mainly due to the low signal intensity. Here, we report direct full-field magnetooptical observation of Barkhausen avalanches in Co thin films by means of magnetooptical microscope magnetometer (MOMM), capable of time-resolved domain observation, which provides experimental evidence for the validity of a phenomenological model of Barkhausen avalanche originally proposed by Cizeau *et al.*[2].

2. EXPERIMENT

We study a real-time domain dynamics of Barkhausen avalanche in Co thin films by means of a MOMM which basically consists of a polarizing optical microscope utilizing longitudinal Kerr effect. The spatial resolution is 2 ㎛ and the Kerr angle resolution is 0.1° in this setup. To store domain images, the system is equipped with advanced video processing having an image grabbing rate of 30 frames/s. The Barkhausen avalanche was triggered by applying a constant magnetic field to an initially saturated sample. We prepared several Co films having thickness comparable to the typical domain-wall width of 50 nm to avoid the magnetization change along the film thickness direction. Films were deposited on glass substrates by dc-magnetron sputtering under 2 x 10^{-7} Torr base pressure and 2 mTorr Ar sputtering pressure.

3. RESULTS AND DISCUSSION

Domain evolution patterns clearly exhibit discrete and jerky jumps in magnetization reversal

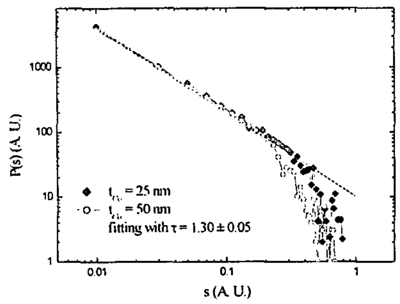

Fig. 1. Distributions of Barkhausen jump size in 25 and 50-nm Co samples.

process. As the experiments are repeatedly performed at the same area of the film, magnetization reversal proceeds with quite different jumps every time. A visualization of domain evolution by means of the MOMM enables us to directly witness the randomness of location, in addition to the randomness of interval and size of the jumps, from which one could relate these jumps to the Barkhausen avalanches. Barkhausen jump size is determined from the direct measurement of abrupt areal change of real-time domain patterns. Through a statistical analysis of the fluctuating size of Barkhausen jump from 1000-times repetitive experiments for each sample, the distribution of Barkhausen jump size s was obtained. The distribution is found to exhibit power law behavior and fitted as $P(s) \sim s^{\tau}$ with critical exponent $\tau = 1.30 \pm 0.05$ as plotted in Fig. 1.

Our observation revealed that there exist flexible 180^{0}-type domain walls deformed by defects, where the domain wall was still flexible even in strong pinning case. Images of domain walls around the strong pinning site were repeatedly obtained at the same area and then, they were superimposed. The resultant image is illustrated in Fig. 2, where the pinning site is indicated by the solid arrow and domain wall intersecting this pinning site jump to the other state as indicated by the dotted arrow. We want to emphasize that all our experimental results directly confirm the validity of the model proposed by Cizeau *et al.*, where it was assumed that the flexible 180^{0}-type (d-1)-dimensional domain wall moves with Barkhausen jumps as deformed by localized defects. We conclude that the prediction of τ from the model (1.33) for two-dimensional system is consistent with our experimental result (1.30 ± 0.05) for Co thin films. We propose this model, which successfully describes three-dimensional soft-magnetic bulk systems can be extended to two-dimensional thin films.

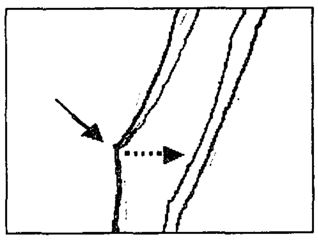

Fig. 2. Superimposed domain walls from repeated experiments in a case of strong pinning site.

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4. REFERENCES

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