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Co/Pd 다층박막의 local 자기보자력 측정

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Local coercivity variation of Co/Pd nanomultilayers

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1. INTRODUCTION

Ultrathin ferromagnetic films and nanomultilayers are of great interest in recent years[1,2]. To achieve the high performance of the nanomagnetic applications it is necessary to prepare the materials nanoscopically uniform[3-5]. Recently, we have developed the local hysteresis loop measurement technique within the optical resolution limit by adopting a magnetooptic Kerr microscopic system. In this study, we have investigated the local coercivity distribution of the Co/Pd nanomultilayers having perpendicular anisotropy by measuring the local hysteresis loops. The contrasting domain configuration and reversal behavior of the Co/Pd nanomultilayers reported by Choe and Shin[5] has been re-examined in accordance with the local coercivity distribution.

2. EXPERIMENTS

A high-performance Kerr microscopic system has been developed to measure the local hysteresis of magnetooptic thin films having perpendicular magnetic anisotropy[6,7]. The system mainly consists of an optical polarizing microscope capable of x1,000 magnification. To measure the hysteresis, the system is equipped with an electromagnet controlled by a personal computer to sweep the external magnetic field over the range of ± 5 kOe. The domain images are captured by an advanced CCD camera system. The images are composed of the light intensity distribution measured by the CCD array of 100x80 pixels, where a unit pixel corresponds to the area of 0.32x0.32 μm^2 at the film surface. Storing the domain images with sweeping the external magnetic field it is possible to obtain the array of the local intensity function I_{xy}(H) by tracing the intensity variation, with sweeping the external field H at every corresponding $(x,y)th$ CCD pixels.

The local coercivity distribution of Co/Pd nanomultilayers has been investigated. Samples of (2-Å Co/11-Å Pd)$_n$ with varying the number of repeats n, were prepared on glass substrates by e-beam evaporation. The layer thickness was controlled within a 4% accuracy by the thickness-control technique using real-time thickness measurement[6].

3. RESULTS AND DISCUSSION

Interestingly, the local coercivity distribution was found to be very sensitively increased with increasing the number of repeats n. In Figure 1, we illustrate the local coercivity distribution of (a) n = 10 and (b) 18, respectively, by mapping $\delta H_C(x,y)$ in gray level on the 2-dimensional XY plane where the area of the maps corresponds to 32.8x26.2 μm^2 at the sample surface. It is very surprising that the local coercivity distribution was very contrastingly changed with increasing the number of repeats n: the thinner film with n = 10 shows a smooth variation of the local coercivity as shown in Figure 1(a), while the thicker film with n = 18 shows a large fluctuation of the local coercivity as shown in Figure 1(b). The large fluctuation of the local coercivity of the thicker film is possibly ascribed to a larger amount of the structural irregularity, because the local structural irregularity such as atomic misfit, defects, and dislocations, may be accumulated during the film deposition. The local structural irregularity is known to cause the magnetic inhomogeneity such as the misorientation of the polycrystalline axis, the reduction of the nucleation field, and the domain-wall pinning

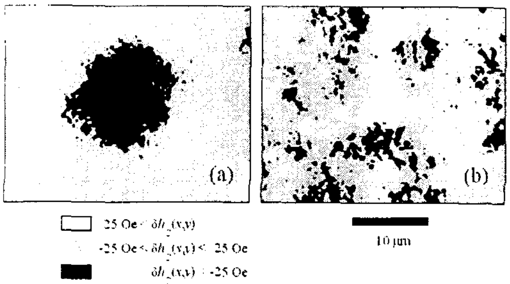

FIG. 1. Local hysteresis variation: (a) (2-Å Co/11-Å Pd)$_{10}$ (b) (2-Å Co/11-Å Pd)$_{18}$

effect[8].

Magnetization reversal behavior of the Co/Pd nanomultilayer samples have been investigated by time-resolved observation of domain evolution from the saturated state under a reversed applied field[6,7]. The reversal phenomena in this system was found to be very sensitively changed from wall-motion dominant to nucleation dominant with increasing the number of repeats[5]. Figure 2 shows the typical domain patterns of the samples of (a) n = 10 and (b) 18, respectively, during the magnetization reversal. A large domain is clearly observed in Figure 2(a), while a number of small domains are seen in Figure 2(b). These contrasting reversal patterns are occurred by the counterbalance between the nucleation process and the wall-motion process[3-5]: the large domain shown in Figure 2(a) is formed by the wall-motion process from a single nucleation site, while the small domains in Figure 2(b) are nucleated by the nucleation process irrespectively to existing domains.

It is very interesting to note that these contrasting reversal patterns are quite well coincident with the local coercivity distributions for each corresponding sample. The reversal mechanism under the local coercivity variation has been analyzed based on the thermally activated relaxation process. The half reversal time $\tau(x,y)$ is locally irregular even under a spatially-uniform applied field H, because $\tau(x,y)$ is proportional to the value of $\exp(V_A M_S \delta H_C / k_B T)$. Since the magnetization reversal is primarily occurred at

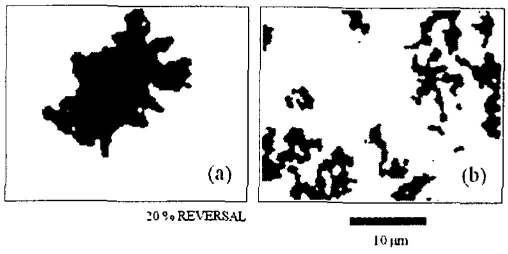

FIG. 2. Domain patterns during reversal: (a) (2-Å Co/11-Å Pd)$_{10}$ (b) (2-Å Co/11-Å Pd)$_{18}$

the regions of faster $\tau(x,y)$, the domain reversal pattern is sensitive to the local reversal time variation. As the local coercivity variation is increased, the wall-motion is pinned at the regions of slower reversal speed and then, the reversal proceeds by the nucleation at the regions of faster reversal speed irrespectively to the existing domains. This type of reversal behavior is empirically perceived as a nucleation dominant reversal. On the other hand, the reversal behavior under a smooth coercivity distribution is dominated by the wall-motion overcomming the less wall-pinning effect.

References

[1] P. F. Carcia, A. D. Meinhaldt, and A. Suna, Appl. Phys. Lett. **47**, 178 (1985).

[2] S.-C. Shin, Appl. Surf. Sci. **65**, 110 (1993).

[3] H.-P. D. Shieh and M. H. Kryder, IEEE Trans. Magn. **24**, 2464 (1988).

[4] J. Pommier, P. Meyer, G. Ponissard, J. Ferre, P. Bruno, and D. Renard, Phys. Rev. Lett. **65**, 2054 (1990).

[5] S.-B. Choe and S.-C. Shin, J. Appl. Phys. **83**, 6952 (1998); **85**, 5651 (1999).

[6] S.-B. Choe and S.-C. Shin, Phys. Rev. B, **57**, 1085 (1998); J. Appl. Phys. **81**, 5743 (1997).

[7] S.-B. Choe and S.-C. Shin, Appl. Phys. Lett. **70**, 3612 (1997).

[8] H. Kronmuller, Phys. Stat. Sol. (b) **144**, 385 (1987).