QE08

Observation of Multiple Transitions on Permalloy Ring by Magnetic Force Microscopy

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Over the past few years, the magnetization reversal and the corresponding magnetic domain configurations of micron-sized ferromagnetic ring structures have been investigated extensively [1-4] due as much to the interesting studies of fundamental physics as to their potential for applicationsin magnetic random access memory (MRAM) [5]. The most important key issue is to understand and control the magnetic switching precisely. Among recent studies, ferromagnetic ring structures have been shown not only to possess stable remanent states of flux-closure vortex or onion, but to form vortex-pair state [6] and vortex-core state [7,8] during magnetization reversal. Herein, we present a study of magnetization reversal on micron-sized permalloy ring structures using a magnetic force microscopy in the presence of external field for probing directly the magnetization evolution during switching process. In addition, a numerical simulation using OOMMF [9] was implemented for detailed exploration. Figure 1 shows a series of MFM images taken in the presence of various external fields and the corresponding simulated results. Notice that a multiple transition is observed and the experimental results are supported by the simulation. The multi-stable states in the magnetization reversal may provide excellent chance of developing multibit storage cells.

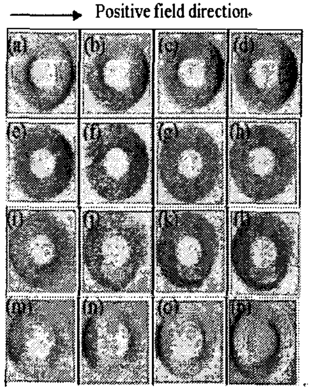

Fig. 1. A series of MFM images of the large ring with the outer and inner diameter of 5 and 2.2 m and thickness of 23 nm. The images were taken at theapplied field of (a)540 Oe (b)216 Oe (c)140 Oe (d)108 Oe (e)54 Oe (f)11 Oe (g)0 Oe (h) -11 Oe (i)-44 Oe (j)-47 Oe (k)-49 Oe (l)-54 Oe (m)-60 Oe (n)-98 Oe (o)-162 Oe (p)-540 Oe, respectively.

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QE09

Direct Observation of Surface Magnetic Field Distribution Using Scanning Magnetoresistance Microscopy

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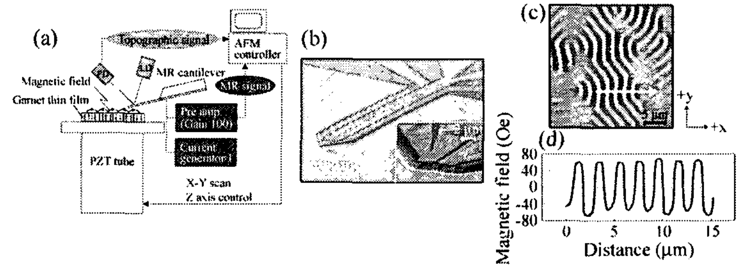
Magnetic imaging techniques with high spatial resolution have been of great interest for studying magnetism in thin films and small magnetic elements. Various techniques using scanning probe microscopy (SPM) have been proposed to measure magnetic fields emanating from sample surfaces. We have developed a new scanning magnetoresistance microscope (SMRM). In the SMRM, we employed an integrated atomic force micropscopy (AFM) cantilever with an MR sensor (MR cantilever) to simultaneously obtain topographic and magnetic fieldinformation. (Figure (a)) [1] In this paper, we have fabricated a new high sensitive MR cantilever with an exchange-biased spin-valvle (SV) type MR sensor. We report on magnetic field distribution imaging using the SMRM with the newly developed high sensitive MR cantilever.

The MR cantilever with an exchange-biased SV sensor was fabricated using photo and electron beam lithography, liftoff, Si bulk micromachining, and so forth. [1, 2] Figure (b) shows a scanning electron micrograph of a fabricated MR cantilever. A rectangular SV sensor (500 nm wide and 3 μm long)is located at the apex of the cantilever. The SV sensor was designed to have a linear response to the magnetic field component parallel to the long direction of the MR cantilever. Figure (c) shows a magnetic field distribution image of a magnetic garnet thin film. This SMRM image reflects the maze-like domain structure of the garnet sample and this means that the SMRM can observe magnetic distribution emanating from the garnet sample. The image is composed of 512 × 256 pixels and the brightness of each pixel corresponds to the output voltage (MR signal) of the SV sensor. The detecting direction is parallel to the x direction component of the magnetic fields. The contrast of this image corresponds to the direction of the measured magnetic fields. The bright areas represent +x direction component of the magnetic fields. Figure (d) shows the cross sectional profile in the line indicated by the arrow in the Fig. (c). In Fig. (d), the MR signal of the SV sensor is converted into the magnetic field strength. In this paper, we have demonstrated that the SMRM can determine the direction and strength of the stray magnetic field emanating from the ferromagnetic sample surface.



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