CT03

Creation and Manipulation of Surface Magnetic Domains in an Alternating Up-and-Down Pattern

Guan-Chun Xie, Shun-Yu Gao, and Yuan-Ron Ma*
Department of Physics, National Dong Hwa University, Hualien 97401, Taiwan, Republic of China
*Corresponding author: E-mail: ronma@mail.ndhu.edu.tw

Since the two basic scanning-probe-microscopy-baased (SPM-based) technologies: scanning tunneling microscopy (STM) and atomic force microscopy (AFM) have been involved in selective surface modifications with a precise localization of the induced artificial pattern, the scanning probe microscopy (SPM) becomes an essential tool in the fabrications of atomic or nanoscale structures. The scanning probes (or tips) of the STM or AFM have been exploited to disturb surface absorbates or substrate surfaces, such as with lateral manipulations of atoms and molecules, vertical transports of atoms and molecules, local anodic oxidations, probe lithography and dip-pen nanolithography, and so on, for aims at building blocks that can be used as atomic- or nano-devices. Even, the AFM has been specifically designed to "pull" biomolecules to understand the mechanism of single-molecule protein unfolding, which provides an excellent ability to explore regions of the protein energy landscape. Magnetic force microscopy (MFM) probes have been recently used to agitate surface magnetic domains (SMDs) of ferromagnetic $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) thin-films and then induce magnetic ripple patterns on the surfaces, because as the temperature rose toward the Cuire temperature (T_c) domain-domain interaction became weaker and SMDs became highly mobile.

In this study, we assume that the surface magnetic configurations of magnetic samples can be not only observed but also agitated by a magnetic probe such as that was operated in tapping-mode. An approach to the agitation of the SMDs on the soft ferromagnetic LSMO surface using an oscillating magnetic probe is presented. Because of its pyramidal geometry, the magnetic probe's magnetization is retained in a vertical component normal to the sample surface. To be precise, the magnetic field of a magnetic probe is usually oriented along its axes. It has been shown in many magnetic force microscopy (MFM) studies [1, 2] that the probe-sample magnetic interaction (an essential factor) disturbs the surface magnetic configuration of the thin films. No other external perturbation is needed. According to Lenz's law, the SMDs on the LSMO surface can be agitated and flipped in response to a change in the magnetic flux depending upon whether the oscillating magnetic probe is approaching to or leaving away from the LSMO surface. We found that we could indeed use an oscillating magnetic probe to induce out-of-plane magnetization SMDs on the LSMO surface, thus confirming that the validity of this approach. We successfully induced out-of-plane SMDs from the in-plane magnetization, and manipulated them in an alternating up-and-down pattern.

REFERENCES

[1] Th. Kebe, A. Carl, J. Appl. Phys. **95**, 775 (2004).
[2] M. Liebmann, A. Schwarz, U. Kaiser, R. Wiesendanger, D.-W. Kim, T.-W. Noh, Phys. Rev. B **71**, 104431 (2005).

CT04

Effect of Microstructure Changes on Barkhausen Noise Properties and Hystersis Loop in Cold-rolled Low Carbon Steel

Hiroaki Kikuchi*, Katsuyuki Ara, Yasuhiro Kamada, and Satoru Kobayashi
Iwate University, 4-3-5 Ueda , Morioka, Japan
*Corresponding author: Hiroaki Kikuchi, e-mail: hkiku@iwate-u.ac.jp

Since Barkhausen noise (BN) is very sensitive to microstructures of materials, it has been used as a tool for characterization or nondestructive evaluation (NDE) of ferromagnetic materials. There have been investigations of BN changes under various conditions including fatigue, irradiation, stress and so on [1-3]. However, the effect of microstructure changes induced from cold rolling on BN has been rarely investigated. Therefore we investigated correlations between BN energy and mechanical properties for cold-rolled low carbon steel [4]. In this work, BN characteristics for cold-rolled steels are studied in relation to their microstructure changes and hysteresis loop characteristics. Low carbon steel plates deformed by cold rolling with the reduction ratio of 0 to 40 % were magnetized by a triangular wave of 1 Hz by using a Fe-Si yoke. The original BN signal was picked up by an air-core coil located on the surface of a plate, and BN parameter, rms voltage, was analyzed, and hysteresis loops were also measured. Fig. 1 shows the dependence of the rms voltage on the magnetizing current. The peak in rms voltage increases rapidly up to 10 %, then gently with increasing reduction ratio. The magnetizing current at which the rms voltage takes a maximum, also increases as reduction ratio increases. Dislocation density increases sharply first and gently over 20 % with the increase in reduction ratio [4]. On the other hand, a higher reduction ratio induces a large number of smaller cell structures. This may not increase the number of pinning site but enhance interactions between pinning sites and domain walls (DWs). Consequently, the number of pinning site affects the peak intensity, and the magnetizing current at peak is attributed to the intensity of interactions between pinning sites and DWs. Thus, BN parameter changes can be discussed based on the microstructure changes and will be understood in relation to a parameter, such as coercive force, determined from a hysteresis loop.

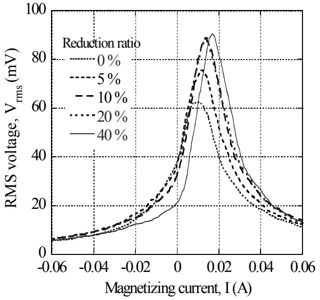

Fig. 1. Dependence of rms voltage on magnetizing current.

REFERENCES

[1] C. C. H. Lo, *et al.*, IEEE Trans, Magn., 40, 2173 (2004).
[2] S. Palit Sagar, *et al.*, Int. J. Fatigue, 27, 317 (2005).
[3] V. Moorthy, *et al.*, Acta Mater., 52, 1927 (2004).
[4] T. Liu, *et al.*, J. Magn. Magn. Mater., 310, e989 (2007).