Controllable Pinning of Domain Walls With Specific Structures by Magnetostatic Interaction

Cheong-Gu Cho*, Sang-Cheol Yoo, Sung-Min Ahn, Kyoung-Woong Moon and Sug-Bong Choe
Department of Physics, Seoul National University, Seoul, 151-747, Republic of Kor

자구벽 운동에 대한 연구가 활발히 진행되면서 자구벽의 거동을 정확히 제어하는 것이 중요한 화두가 되었다. 특히 기존에 제안되었던 나노선 구조를 변형시킴으로써, 자구벽의 디피닝 현상을 제어하는 방법은 자구벽의 형태와 구조를 변형시키는 단점으로 지적되어 왔다. 본연구는 정자기 상호작용을 이용하여 기존의 강자성체 나노선의 구조를 변형시키지 않고 자구벽을 포획하는 방법을 제시하고자 한다. 나노선과 나노막대 사이의 정자기적 상호작용을 구현하기 위해 $Ni_{81}Fe_{19}$를 스퍼터링을 통해 두께 20nm 증착하였으며, E-beam lithography를 이용하여 넓이 300nm 나노선과 나노막대를 구현하였다. 자구벽 운동을 측정하기 위하여 (MOKE)를 이용한 디피닝 자기장의 세기를 측정하였다.

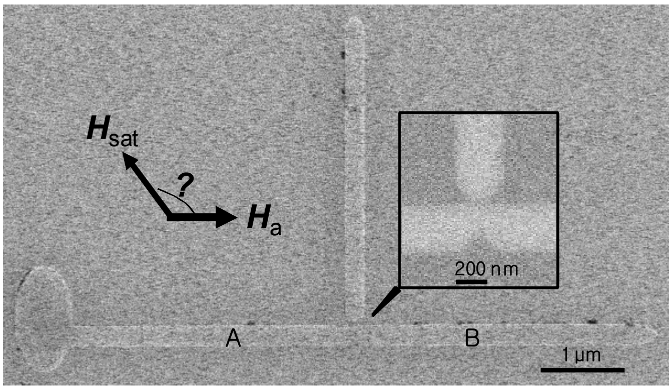

Fig. 1. SEM image of $Ni_{81}Fe_{19}$ nanowire with a notch and a nanobar perpendicular to each other. Inset: High resolution image of the nanobar ending vertical to nanowire.

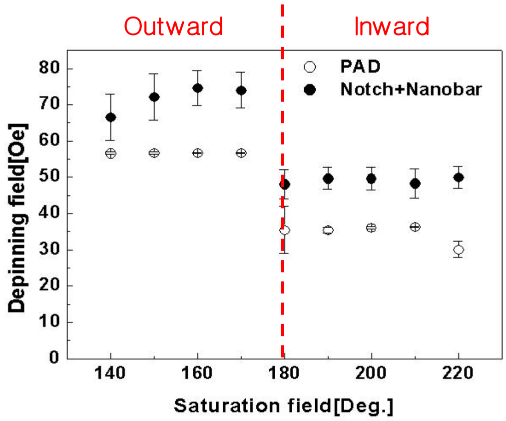

Fig. 2. Depinning field with respect to the angle of satuation magnetic field and measuring points, such as A and B. Open and closed circles indicate depinning fields from pad and notch with stray field caused by end of nanobar, respectively.

It is important to understand physically how to control the domain wall (DW) accurately and reliably, because the field required to depiningthe DW from a constriction is sensitive to the DW structure and chirality[1,2]. Furthermore, the ability to control the depinning behavior of a domain wall through the geometrical structures of the magnetic wire allows the experimental study of fundamental physical properties of the DW motion. 280 nm wide, 10 nm thick permalloy nanowire with a notch and a nanobarwere fabricated using electron beam lithography, with edge to edge separation less than 30nm and a asymmetrical pad, [3-4] as shown in Fig. 1. The arrows indicate the magnetic field directions of H_{sat} and H_a are saturation field and horizontally applied field. The depinning behaviors are monitored by the Magento-Optic Kerr Effect (MOKE) signal detection at position A and B using a longitudinal MOKE measurement system. Figure 2 summarizes the DW depinning field from the pad and the notch according to the angle of saturation field. It is clearly seen from open and closed circles as shown in Fig. 2. that chirality-controlled DW is injected into the nanowire and the DW is pinned by external pinning force from the notch and the stray field generated from a diverging magnetostatic charge generated by the nanobar. According to our results, the outward or inward direction of magnetization of the nanobar affects the shape of the main potential experienced by the DW, whereas the pinning strength strongly depends on interaction with external pinning force of the notch.

This work is supported by NRF funded by MEST through Mid-career Researcher Program (2007-0056952, 2009-0084542).

[1] D. Petit *et al.*, Phys. Rev. B, **79**, 214405 (2009).
[2] D. Atkinson, D. S. Eastwood, and L. K. Bogart, Appl. Phys. Lett. **92**, 022510 (2008).
[3] D. McGrouther, S. McVitie, J. N. Chapman, and A. Gentils, Appl. Phys. Lett., **91**, 022506 (2007).
[4] A. Kunz, and S. C. Reiff, Appl. Phys. Lett., **94**, 192504 (2009).