Magnetization Switching Assisted by Spin Wave Dynamics

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1. Background

Magnetic storage and spintronic devices face a serious challenge in trying to simultaneously achieve ultrahigh-density recording and ultralow power operation. In other words, a nanomagnet with high magnetic anisotropy energy needs to be switched by applying a small external magnetic field. We reported low-field magnetization switching assisted by spin wave dynamics, which is called "spin wave-assisted magnetization switching".[1)] In previous experiments,[1-4)] we employed the in-plane magnetized exchange-coupled bilayers having hard magnetic $L1_0$-FePt and soft magnetic $Ni_{81}Fe_{19}$ (Permalloy), and observed a large reduction in the switching field (H_{sw}) of $L1_0$-FePt by exciting the perpendicular standing spin waves (PSSW) in the Permalloy. From a practical point of view, however, this concept is needed to apply the "perpendicularly magnetized system". In addition, the detailed switching process of spin wave-assisted magnetization switching has not fully been understood yet.

In this talk, we show (i) spin wave-assisted magnetization switching for the exchange-coupled bilayers with perpendicular configuration. In addition to the study on the perpendicular configuration, (ii) the resonant switching behavior of spin wave-assisted magnetization switching is discussed using the in-plane magnetized exchange-coupled bilayers.

2. Spin Wave-Assisted Magnetization Switching in Perpendicularly Magnetized System

We investigated the magnetization dynamics of exchange-coupled bilayers with a perpendicularly magnetized $L1_0$-FePt and a soft magnetic Permalloy. The $L1_0$-FePt (001) layer was epitaxially grown on an MgO (100) single crystal substrate with an Au (001) buffer layer. In order to examine the effect of magnetization dynamics on H_{sw} of the perpendicularly magnetized $L1_0$-FePt, we exploited a nanodot consisting of the $L1_0$-FePt layer and the soft magnetic Permalloy layer having a magnetic vortex. The $L1_0$-FePt layer exhibited H_{sw} = 8.6 kOe without the application of rf magnetic field (H_{rf}). When H_{rf} = 200 Oe with the frequency (f) of 11 GHz was applied, H_{sw} was reduced to 2.8 kOe. By comparing the experimental result with the micromagnetic simulation, we found that the vortex dynamics of azimuthal spin waves in Permalloy effectively triggered the reversed-domain nucleation in $L1_0$-FePt at a low magnetic field (H). Our results demonstrate that the excitation of spin waves in the magnetic vortex leads to the efficient H_{sw} reduction even for the exchange-coupled system having the perpendicularly magnetized $L1_0$-FePt.[5)]

3. Resonant Switching Condition of Spin Wave-Assisted Magnetization Switching

In order to understand the detailed switching condition of spin wave-assisted magnetization switching, we mapped the switching events in the H - f planes for the exchange-coupled bilayers, where $L1_0$-FePt and Permalloy layers showed in-plane magnetization. The magnetization switching was observed only in a limited region following the dispersion relationship of PSSW modes in the Permalloy layer. The experimental result and the numerical simulation indicate that spin wave-assisted magnetization switching is a resonant magnetization process. This is a characteristic behavior and different from the conventional microwave assisted switching. Our results also suggest that spin wave-assisted magnetization switching has the potential to be applied to selective switching for multilevel magnetic recording media.[6)]

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