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Fabrication of Perpendicularly Magnetized $L1_0$-FePt / Permalloy Nanodots with a Twisted Spin Structure

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[Introduction] The ever-increasing storage density of magnetic storage devices has led to the utilization of high magnetic anisotropy (K) materials, *e.g.* $L1_0$-FePt, as recording media. Meanwhile, a high coercive field (H_c) caused by the high K gives rise to a high switching field (H_{sw}) for writing information, which is not suitable for the recent trend of device operation with low power consumption. To overcome this dilemma, Seki *et al.* [1] reported a switching method called spin wave-assisted magnetization switching. The exchange-coupled bilayer film consisting of a Permalloy ($Ni_{81}Fe_{19}$; Py) layer and an in-plane magnetized $L1_0$-FePt layer showed a spatial twisted spin structure, and the magnetization of the hard magnetic $L1_0$-FePt layer could be switched at an extremely low magnetic field by utilizing the spin wave modes in the soft magnetic Py layer. For practical applications, however it is important to demonstrate the spin wave-assisted magnetization switching in a perpendicularly magnetized system. To begin with, the preparation of a perpendicularly magnetized hard / soft magnetic bilayer is necessary. In this study, we investigated the magnetic properties of the microfabricated $L1_0$-FePt / Py nanodots, where $L1_0$-FePt was magnetized perpendicularly to the film plane. We evaluated its spring back behavior due to the exchange coupling between the $L1_0$-FePt and the Py layers.

[Experiment] The stacking of the thin films was MgO (100) subs. // Fe (2 nm) / Au (30 nm) / FePt (10 nm) / Py (150 nm) / Au (5 nm). The FePt (001) layer was epitaxially grown on the Au (001) buffer layer at 550ºC, in order to promote the $L1_0$ ordering of the FePt (001) layer with perpendicular magnetization. Other layers were deposited at ambient temperature. The thin films were microfabricated through the use of electron beam lithography and Ar ion milling. The continuous film was patterned into circular dots with the sizes around 200 nm in diameter. After patterning the continuous film into the dot shapes, a clear change in the magnetization curves was observed. H_c of the FePt layer increases from 400 Oe for the continuous film to 7 kOe for the dots. The spring back behavior of the dots was examined by measuring the minor magnetization curves, and the spring back ratio (ε) [2,3] was evaluated. The value of ε was larger than 0.9 when the spring back field (H_{sp}) was swept in the range from 0 to -5 kOe. The reversible minor magnetization curves indicate the exchange coupling between $L1_0$-FePt and Py and the formation of twisted spin structure in the perpendicularly magnetized system.

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[3] K. Utsumiya, T. Seki, and K. Takanashi: *J. Appl. Phys.*, **110**, 103911 (2011).