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スピン波アシスト磁化反転における磁化ダイナミクス

Magnetization Dynamics of Spin Wave-Assisted Magnetization Switching

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[Introduction] The reduction of magnetic volume with maintaining the thermal stability of magnetization is an indispensable issue for the development of ultrahigh density magnetic recording media. A high magnetic anisotropy material leads to the good thermal stability of magnetization at a reduced dimension. However, it simultaneously gives rise to the difficulty of magnetization switching. In order to solve this problem, we have proposed a magnetization switching method: *spin wave-assisted magnetization switching*. This switching method utilizes the spin wave mode in $L1_0$-FePt / Permalloy (Py) exchange-coupled bilayers, which is a kind of perpendicular standing spin wave (PSSW) mode. We can significantly reduce the switching field (H_{sw}) of the $L1_0$-FePt layer when the PSSW is excited. In this study, we carried out the systematic investigation to understand the detailed magnetization dynamics of spin wave-assisted magnetization switching.

[Experimental procedure] Thin films were prepared on an MgO (110) single crystal substrate. The stacking structure of the thin film is MgO (110) subs. // Fe (1 nm) / Au (40 nm) / $L1_0$-FePt (10 nm) / Py (t_{Py} nm) / Au (3 nm). All the layers except the $L1_0$-FePt layer were deposited at room temperature. The $L1_0$-FePt layer was deposited at 450 ºC to promote the $L1_0$ ordering. The $L1_0$-FePt layer has the easy magnetization axis along the [001] direction in the film plane. The thin films were patterned to a rectangular element with the size of 2 μm × 50 μm through the use of electron beam lithography and Ar ion milling. An anisotropic magnetoresistance effect was measured using a lock-in amplifier to determine H_{sw} under the spin wave excitation. A signal generator was employed to apply rf magnetic field (H_{rf}), which enabled us to excite the spin wave in the bilayers.

[Results and discussion] For t_{Py} = 120 nm, H_{sw} was significantly decreased from 1700 Oe to 200 Oe when H_{rf} with the excitation frequency of 8 GHz was applied. This excitation frequency coincided with the resonant frequency of the PSSW mode. We investigated H_{sw} as a function of the excitation frequency under the static magnetic field with various in-plane angles (θ), and it was found that H_{sw} showed the minimum around 8 GHz regardless of θ. This tendency is different from that observed in microwave-assisted magnetization reversal using the uniform magnetization procession mode [1]. The characteristic θ dependence is attributable to the weak θ dependence of resonant frequency of the PSSW mode. Our numerical simulation well reproduced the experimental result of H_{sw} as a function of the excitation frequency, and indicated that the magnetization switching was triggered by the large amplitude of the spin wave excitation in the Py layer. We also examined the magnetization switching behavior under the high power spin wave excitation.

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