Spin-orbit torque induced magnetization switching in perpendicularly magnetized MnGa/Fe bilayer grown on GaAs

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1. Introduction

Perpendicularly magnetized thin films grown on semiconductors are essential for vertical spin sources of spin-based semiconductor devices, such as spin transistors and spin-LEDs. Towards realization of these spintronic devices, electrical manipulation of magnetization direction with high speed, low power, high write endurance, and high selectivity is requisite. Recently, we reported a clear perpendicular magnetic anisotropy (PMA) of MnGa/Fe bilayer grown on GaAs [1]. In this study, we investigated a spin-orbit torque (SOT) induced magnetization switching of MnGa/Fe bilayer grown on GaAs.

2. Experimental Methods

A layer structure consisting of (from the surface side) MgO cap (2)/Ta (5)/MnGa (2)/Fe (0.6)/GaAs buffer (700) was deposited on a GaAs(001) single-crystal substrate. The numbers in parentheses are nominal thicknesses in nanometers. The Fe and MnGa layers were deposited at RT, and they were annealed at 200°C to improve the crystalline quality. The layer structure was processed into Hall devices with a 5-μm-wide channel to evaluate the magnetic properties and SOT-switching characteristics.

3. Results and Discussion

Figure 1 shows out-of-plane MOKE signals for the MnGa/Fe bilayer. We observed clear PMA of the bilayer, including a Fe layer due to the ferromagnetic exchange coupling with MnGa.

Figure 2 shows current-induced magnetization switching for MnGa/Fe. We observed clear SOT switching under an in-plane magnetic field H_x. The switching current density in the Ta layer was 1.5×10^7 A/cm^2, which was less than half that of 2-nm-thick MnGa single layer [2], possibly due to the reduction of the anisotropic magnetic field by inserting a Fe layer.

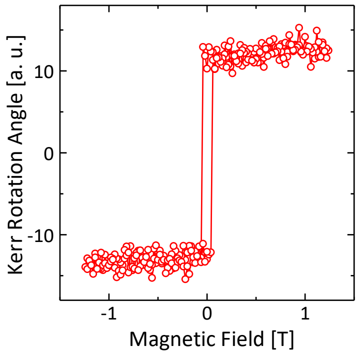

Fig. 1. MOKE signal of a MnGa/Fe film as a function of out-of-plane magnetic field.

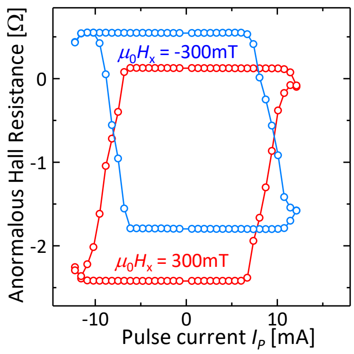

Fig. 2. Anomalous Hall resistance of MnGa/Fe as a function of pulse current I_p with the duration of 1 ms under $\mu_0H_x = \pm0.3$ T.

Acknowledgements

This work was supported in part by JSPS KAKENHI (20H02598, 20H02174), MEXT X-NICS (JPJ011438), MEXT ARIM (JPMXP1222HK0071), and JST CREST (JPMJCR22C2).

References

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