Origin and Optical Switching of Perpendicular Magnetization for $Co_{100-x}Gd_x$/Pt Multilayers

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Magnetization manipulation on ultrashort timescales is one of the major issues for developing high speed spintronic devices. All-optical switching (AOS) of magnetization by femtosecond laser pulses has attracted much attention as a route for ultrafast magnetization manipulation. The Gd-based alloys such as Gd-Fe-Co [1] are representative ferrimagnetic materials exhibiting the all-optical helicity independent switching (AO-HIS). However, the detailed process of AO-HIS has not been elucidated yet. The perpendicularly magnetized Gd-based alloys are key materials not only in the AOS experiment, but also in the field of antiferromagnetic spintronics. Although the combinations of Gd-based alloys and Pt have widely been exploited for a variety of studies [2,3], the origin of perpendicular magnetic anisotropy (PMA) has been rarely addressed. These facts make the Gd-based alloys a unique platform to investigate the correlation between the fundamental magnetic properties and the AOS behavior, which will provide knowledge to gain insight into the AOS.

In this study, we paid attention to the combination of Co-Gd and Pt. The origin of PMA and the role of induced magnetic moment were first investigated for the Co-Gd/Pt multilayers with various Co-Gd layer thicknesses (t) and alloy compositions ($Co_{100-x}Gd_x$). Then, the AOS experiments were carried out in order to find the composition dependence of AOS probability. Thin films with the stacking structure of [Pt (2.0)/$Co_{100-x}Gd_x$ (t)]$_{\times 3}$/Pt (2.0) (in nanometer) were prepared on sapphire (11-20) substrates using an ultrahigh vacuum compatible magnetron sputtering system. All the layers were deposited at room temperature.

We found that the PMA mainly comes from the Co-Gd/Pt interface while the contribution from the bulk properties of Co-Gd is negligibly small. The proximity-induced magnetic moment in Pt remarkably appeared for the thin Co-Gd layers, which coupled with the Co moment in parallel. It is noted that the proximity-induced Pt moment largely affected the condition for the magnetization compensation of Co-Gd. The Co-Gd/Pt multilayers exhibited the single laser pulse AO-HIS in the wide Co-Gd composition range, and the maximum AOS probability was obtained around the compensation composition of Co-Gd. The above findings are useful to improve the performance of AOS-based device.

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