TIME AND SPATIALLY RESOLVED XMCD-FMR MEASUREMENT ON A Co/Pt MULTILAYER DOT EXCITED BY RF MAGNETIC FIELD IN THE GHz REGIME

Nobuaki KIKUCHI[1], Hitoshi OSAWA[2], Motohiro SUZUKI[2], Osamu KITAKAMI[1]

1) IMRAM Tohoku University, Sendai, Japan, kikuchin@tagen.tohoku.ac.jp

2) Japan Synchrotron Radiation Research Institute (JASRI), Sayo, Japan

I. INTRODUCTION

Understanding of magnetization dynamics in nanostructures is a crucial issue for further development of magnetic devices. X-ray magnetic circular dichroism (XMCD) using synchrotron lights has advantages against conventional magneto-optic Kerr effect (MOKE), which is widely used to perform time and spatial resolved magnetic measurement. One major advantage is that XMCD can realize element resolved measurement by selecting proper X-ray energy. Another advantage is its shorter wavelength allowing to focus into spot with well below 100 nm. Synchrotron X-ray is suitable also for time resolved measurement because the lights are formed as pulses with typical duration below 100 ps. In this study, we have performed time and spatial resolved XMCD ferromagnetic resonance (FMR) measurement on Co/Pt multilayer dot previously studied by the anomalous Hall effect FMR [1]. Magnetization behavior under rf field with GHz frequency was studied by detecting MCD of polarized Pt layer at the interface with hard X-ray.

II. SAMPLE DETAILS

A gold line of 3 μm in width and 100 nm in thickness was fabricated on a MgO(100) substrate for rf field application. After depositing a SiO_2 layer of 100 nm in thickness for insulation, a Co/Pt multilayer with structure of MgO sub./Ta(0.5)/Pt(1)/Ru(24)/$[Pt(0.5)/Co(1.3)]_4$/Pt(0.5)/Ru(2) was deposited by magnetron sputtering. The numbers in brackets are thickness of each layer in nanometers. The effective perpendicular anisotropy of continuous film was evaluated to be -1.2 kOe. The multilayer was patterned into a circular dot of 2.6 μm in designed diameter by electron beam lithography and ion etching. The dots were located on the gold line therefore the rf magnetic field was applied parallel to the film plane. The sample was mounted on a PTFE printed circuit borad and connected to a rf signal source through SMA connectors and cables. Co/Pt dots with electrodes for anomalous Hall effect (AHE) was also fabricated on the same substrates for comparison.

III. XMCD MEASUREMENT

XMCD measurements was carried out at the hard X-ray beam line BL39XU of SPring-8 [2]. The energy of X-ray was selected to be 11.57 keV of Pt-L_3 edge. X-ray absorption signals were measured by fluorescence mode using a silicon drift detector (SDD). Since the excitation depth of the X-ray in the energy range reaches a few micrometers, the measured signal is averaged one from all Pt layers including the underlayer. The X-ray incident angle was set to be 60 degrees from the film normal to be able to detect in-plane magnetization component by XMCD. Dc magnetic field was applied along film normal using a permanent magnet to saturate magnetization perpendicularly. The dc field strength was set to about 2 kOe so that FMR frequency is in the frequency range of 2-4 GHz. Figure 1 describes the geometry of X-rays, rf and dc fields in this study. The X-ray beam was focused into a spot with dimension of 100 × 250 nm^2 defined by full width at half maximum (FWMH) by using a the Kirkpatrick-Baez (KB) mirror. The duration of X-ray pulse was 60 ps in FWMH. The repetition frequency of X-ray pulse was set to 208 kHz by inserting a chopper [3]. The rf field were applied as pulse trains so that magnetization was reset before each rf field pulse application. The pulse duration and the repetition rate were 100 ns and 208 kHz, respectively. Time and position dependent XMCD measurement were carried out by performing one dimensional scan along z-axis shown in Fig. 1 and

Nobuaki KIKUCHI
E-mail: kikuchin@tagen.tohoku.ac.jp
tel: +81-22-2175359

varying delay of rf field against X-ray pulse. Figure 2 shows relative XMCD signal as functions of delay time and z-axis position measured (a) before applying rf field and (b) 4 ns after applying rf field of 2.5 GHz in frequency. The scanning steps of delay and position are 50 ps and 100 nm, respectively. Before applying rf field, XMCD contrast is uniform in the dot and no time dependence is observed. By applying rf field, clear periodic pattern corresponding to rf field frequency appears against delay. The obtained XMCD contrast does not show significant position dependence. This result indicates uniform precession motion of magnetization was excited over a whole dot within 4 ns.

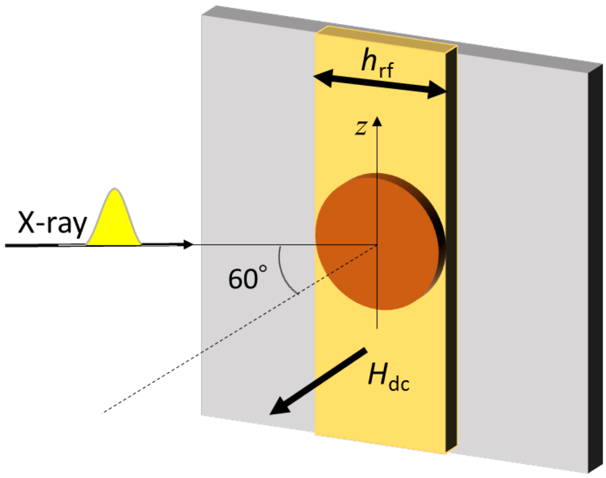

Fig. 1 The geometry of experimental set-up

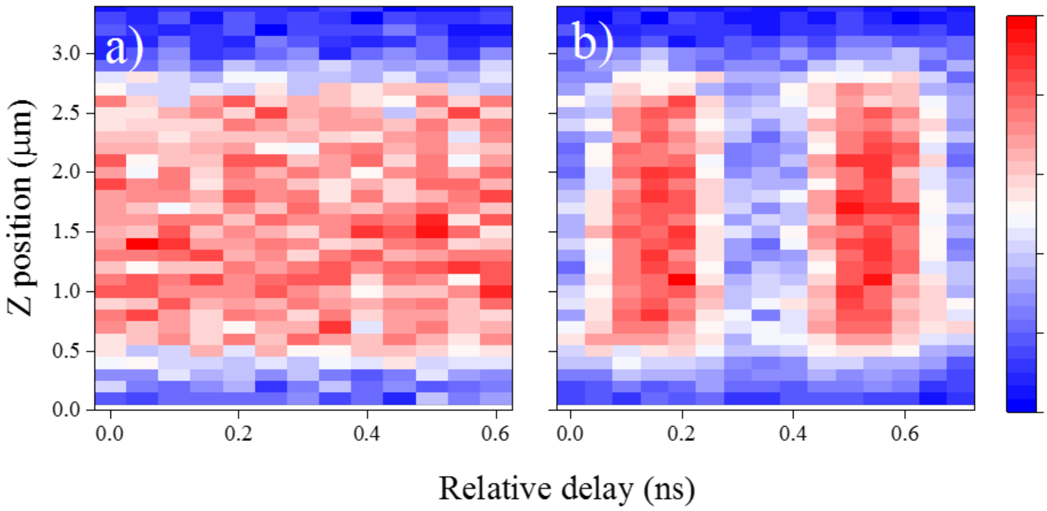

Fig. 2 Relative XMCD signal as functions of position and delay measured (a) before applying rf field and (b) 4 ns after applying rf field of 2.5 GHz in frequency.

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