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Independent All—Optical magnetization Switching of each layers in GdFeCo double layer structure

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All-Optical magnetization Switching[1] (AOS) is triggered within ultra-short interaction time that is shorter than usual external magnetic field driven magnetization switching. The switching on and off strongly depends on absorbed energy fluence[2]. In one of AOS with polarized laser irradiation, helicity of the laser pulse determined the direction of reversed net magnetization M_{net}[3]. In this report, we irradiated a single femtosecond laser pulse to multilayer film and observed The magneto-optical image of the created magnetic domains.We found from this experimrent that this state transition is difficult when this state transition control by external magnetic field.

1. Introduction

In 2007, a new phenomena called All-Optical magnetization Switching was discovered. This phenomenon is magnetization swiching when we irradiate the ultra-short pulsed laser to alloy films of rear earth metals and tranition metals magnetic thin films. We can occur AOS in Rare-earth (RE) and Transitionmetal (TM) ferrimagnet thin films with only ultrafast pulsed laser excitation. AOS has different excitation principle from conventional field driven magnetic recording. The conventional field driven magnetization switching has ferromagnetic resonance (FMR) limit, it makes a limit of switching time is in near ns order. On the other hand, AOS has the different principle of switching and that excitation is sub-ps. So we can expect more rapid magnetic recording with AOS. In addition, we thought AOS allows a new type of multi-value magnetic recording without external magnetic field. In this report, we irradiated a single femtosecond laser pulse to multilayer film and observed The magneto-optical image of the created magnetic domains. We will fabricate a film that has isolated double GdFeCo layers with dielectric layers. These GdFeCo layers has different composition and corecivity *H*c.

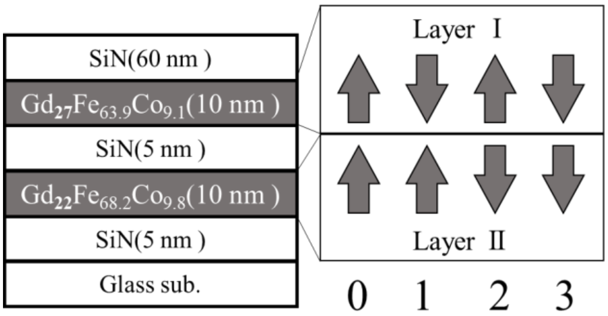

Fig.1 Layer composition of GdFeCo double layer with dielectric interlayer and diagram for magnetization of each

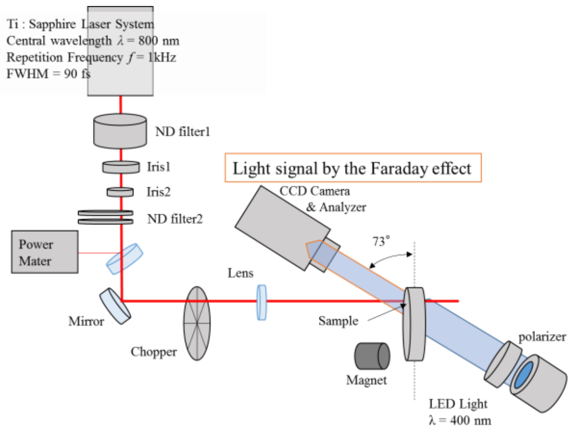

Fig.2 The observation systems for the magnetic domains excitation by femtosecond pulsed laser

2. Method

We designed the film structure which have GdFeCo double layer with dielectric interlayer: SiN (60 nm) / Layer Ⅰ: Gd27Fe63.9Co9.1 (10 nm) / SiN (5 nm) / Layer Ⅱ: Gd22Fe68.2Co9.8 (10 nm) / SiN (5 nm) / AlTi (10 nm) / glass sub. Dielectric SiN interlayer decouple exchange and electric conduction between two metallic GdFeCo magnetic layers. Heavy rare earth Gd and transition metal FeCo sublattice magnetizations are antiparallelly coupled in each perpendicularly magnetized ferrimagnetic GdFeCo alloy layer. The directions of net magnetization (M_{NET}) in Layer Ⅰ and Ⅱ are as same as RE and TM sublattice magnetization (M_{RE} and M_{TM}) in each layer, respectively.(**Fig.1**) The experiments were performed by placing a sample under a polarizing microscope, where domains with magnetization “dark” and “bright” could be obseerved as white and black regions, respectibly. To excite the material we used regeneratively amplified pulses from a Ti:sapphire laser at a wave length of λ = 800 nm, as in **Fig.2**.

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3. Ruslts & Disucussion

Fig.3(a) is θ_F－H courve of GdFeCo double layer film with SiN interlayer measured by magneto-optical faraday effect. This sample has two kinds of different composition ratio magnetic layers (layer Ⅰ and layer Ⅱ). Magneto-optical faraday rotation θ_F of this film include of the rotation from Layer Ⅰ and Layer Ⅱ transition metal magnetization. This figure show there is four manetization state by external magnetic field. **Fig.3(b)** show the magneto-optical images of created domains that is induced by a single femtosecond laser pulse on the multilayer film. In this images ,The round shape magnetization domains are the switched area by AOS. **Fig.3(c)** show the line profile of magneto-optical images is analyzed by image processing software. Fig.3(c) signals has same making of Fig.3(a) signals because, they measured by similar wavelength magneto-optical faraday effect. Example both Layer Ⅰ's magnetization and Layer Ⅱ's magnetization is up direction (state of magnetization is A) when hysteresis loop state is A and that line profile is state of A. After we irradiated a single femtosecond laser pulse sample that state of A changed state of C. This transition of magnetic state can not realized when this state transition is controled by magnetic field. In this report, We irradiated the ultra-short pulsed laser to GdFeCo double layer structure. And we can observed the magneto-optical image of the created magnetic domains. This magnetization switching occurred by only ultra-short pulsed laser. From these result we can obserbed in dependent magnetization swithing of each layer in GdFeCo double layer structure. So this switching is different from field driven recording method.

Acknowledgments

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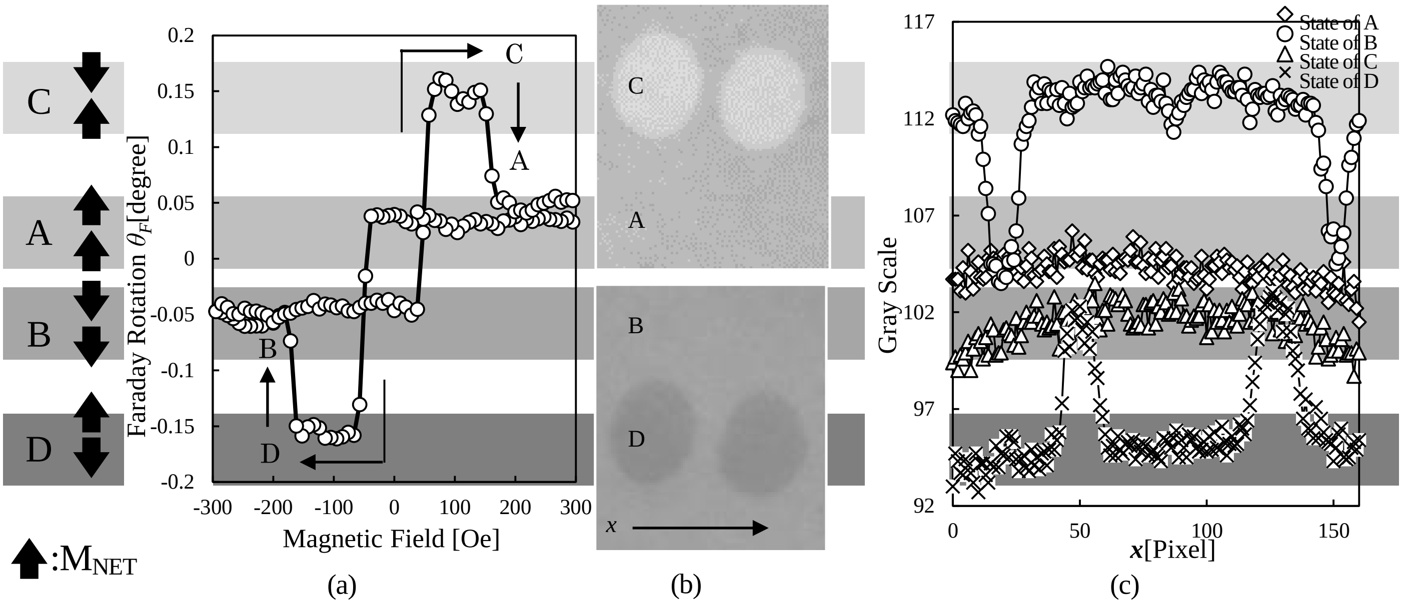

Fig.3 (a) Faraday hysteresis loop of GdFeCo double layer film with SiN interlayer measured by magneto-optical faraday effect. Inset figures show the direction of net magnetization in each magnetic layer. (b)Magnetic contrast of GdFeCo after laser irradiation with single linear polarized laser puleses. (c) The line profile of magnet-optical images in Fig.(b).