C-12

Increase of effective magnetic relaxation in GdFeCo thin film deposited on FePt isolated particles

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Abstract: For faster magnetic recording, a high Gilbert damping magnetic materials is desired. In this research, we attempt to mainly tuning the damping property in magnetic equation of motion. For increase of magnetic relaxation, we proposed an enhancement of energy loss during dynamic motion of magnetization by artificial magnetic inhomogeneity. Therefore, we fabricated sample of GdFeCo thin film exchange coupled with $L1_0$–FePt isolated particles of high magnetic anisotropy energy K_u. This structure creates high density tiny regions having local magnetic inhomogeneity in GdFeCo thin film. In result, we obtained high gilbert damping factor α ~ 0.22 of exchange coupled sample GdFeCo thin layer / $Fe_{62}Fe_{38}$ isolated particle.

1. Introduction

Now a day, a high Gilbert damping magnetic materials is desired for faster recording in our informational society. Gilbert damping factor α of Landau Lifshitz Gilbert (LLG) equation have reciprocal relationship with relaxation time of magnetization precessional motion during magnetization reversal [(1)]. This parameter represents a degree of magnetic energy relaxation phenomena. α includes intrinsic contribution as a natural material property. Therefore, it is difficult to modify only intrinsic α without any change of other material parameters.

In this research, for increase of magnetic relaxation, we proposed an enhancement of energy loss during dynamic motion of magnetization by artificial magnetic inhomogeneity. Therefore, we fabricated sample of GdFeCo thin film exchange coupled with $L1_0$–FePt isolated particles.

This structure creates high density tiny regions having local magnetic inhomogeneity in GdFeCo thin film.

2. Fabricated sample structure

For investigation to enhancement energy relaxation of magnetic continuous thin layer, we used sample structure of GdFeCo thin film / $L1_0$ – FePt isolated particles. GdFeCo thin film has unique magnetic property. Magnetic dynamic property can be easily varying with compensation and temperature. We have already reported enhancement of α (α ~ 0.3) at angular momentum compensation [(1)]. But, effect of enhancement α is depends on composition ratio of Gd and FeCo.

Then, as a scheme to enhance the magnetic relaxation of GdFeCo thin film, we introduced $L1_0$ – FePt isolated particle [(2)]. This material has high uniaxial magnetic anisotropy energy K_u ~ 10^7 erg/cc. Additionally, the in-plane dimensions of FePt isolated particle is as well as domain wall width of GdFeCo (t = 20nm). Thus, high dens FePt isolated particles cause local magnetic inhomogeneity in GdFeCo film. Energy relaxation during magnetic precession motion may be enhanced around these regions. As a result, α is effectively enhanced if all of region of GdFeCo.

In this report, the static and dynamical magnetic properties were investigated as the characteristics of this structure.

3. Sample design and Experiments

We fabricated the samples of SiN (60 nm) / $Gd_{23}Fe_{67.4}Co_{9.6}$ (20 nm) / Pt_xFe_{100-x} nano isolated particle / oxidized Si sub. (x = 55, 57, 62 at. %) as shown in a Figure 1. Hereinafter, a name of sample follows below. A sample of x = 55 at. % referred to as sample "B". A sample of x = 57 at. % referred to as sample "C". A sample of x = 62 at. % referred to as sample "D".

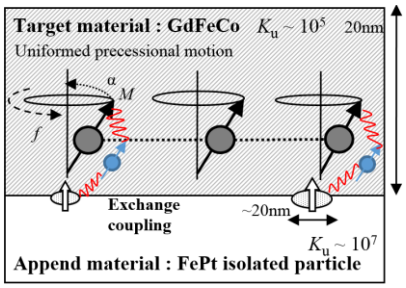

Fig.1 Schematic diagram of GdFeCo thin film stacked on FePt isolated particles

Compare to magnetic property of exchange coupled GdFeCo thin film / FePt isolated particles, we use samples of SiN (60 nm) / $Gd_{23}Fe_{67.4}Co_{9.6}$ (20 nm) / Si sub. This is called sample "A". The average particle size D_a and surface filling ratio of FePt isolated particle are evaluated by surface scanning electron microscope (SEM). The Static magnetic property was evaluated by Vibrating Sample Magnetometer (SQUID - VSM). The Static magneto

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optical property measured by Magneto Optical Kerr Effect (MOKE). Time resolved measurement of magnetic response by optical pump-probe measurement with femto second pulse laser. Gilbert damping factor α is estimated from results.

4. The static property of fabricated sample

Table 1 shows average particle size D_a and surface filling ratio estimated by in-plane SEM image. D_a is confirmed almost 20nm. Furthermore, sparse areal density of particles is around 10%.

Table 1 Property of FePt isolated particles: samples B ~ D

	B	C	D
Composition of FePt particle (Fe:Pt)	55:45	57:43	62:38
Average particle size D_a nm	21.4	19.4	18.9
surface filling ratio %	8.9	10.0	8.9

Figure 2 (a) shows saturation magnetization M_s and uniaxial magnetic anisotropy energy K_u measured by SQUID-VSM. Fabricated samples have appeared magnetic hard phase which is much bigger than GdFeCo thin film.

Figure 2 (b) shows magnetic hysteresis loop of out-of-plane measured by SQUID-VSM. In a measuring process, film was initialized with +70 kOe in all the cases. Clearly coercivity H_c were affected by the stacking structure with GdFeCo on FePt isolated particle. H_c of samples "B" ~ "D" was 6 times increased up to ~ 200 Oe.

Figure 2 (c) shows magneto optical Kerr loop of out-of-plane measured by MOKE. Similarly, with measurement by VSM, a tendency of increase H_c is appeared. It is expected from increase of wall coercivity from exchange coupling between GdFeCo and FePt isolated particles.

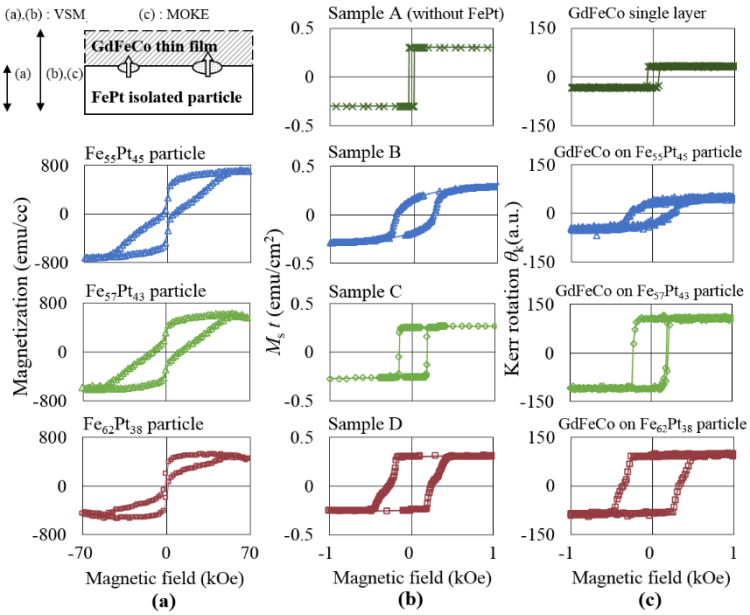

Fig.2 (a): Magnetic hysteresis loops of out-of-plane of FePt isolated particles: sample B ~ D measured by VSM. (b): Magnetic hysteresis loops of out-of-plane of sample A ~ D measured by VSM. (c): Magneto optical Kerr loop of out-of-plane of sample A ~ D measured by MOKE.

5. The dynamic property of exchange coupled GdFeCo thin layer / FePt isolated particle

Figure 3 shows Time resolved measurement of magnetic response by optical pump-probe measurement with femto second pulse laser.

In case of sample "B" ~ "D", α is clearly increased, respectively.

In result, we obtained high gilbert damping factor α ~ 0.22 of exchange coupled sample GdFeCo thin layer / $Fe_{62}Fe_{38}$ isolated particle.

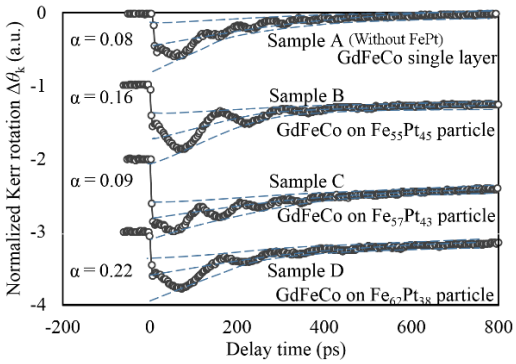

Fig.3 Time resolved measurement of magnetic response by optical pump-probe measurement with femto second pulse laser

6. Summary

In this report, for increase of effective magnetic relaxation in GdFeCo by exchange coupling, we fabricated a structure of GdFeCo thin film / FePt isolated particle. As a result, α have increased up to 0.22. This result suggests a possibility of tuning magnetic relaxation with this structure.

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