C-2

Reduction of Fe dead layer during formation of $L1_0$- FePt grains by introducing a SiN under layer

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Abstract: We already reported that isolated $L1_0$- FePt grains were fabricated by Rapid Thermal Annealing (RTA) and Rapid Cooling Process (RCP) for Pt/ Fe multilayered thin films on thermally oxidized Si (SiO_x) sub. [1, 2]. In the case of initial deposited $Fe_{62}Pt_{38}$ films thickness is 1.88 nm, the coercive force is 42 kOe as maximum [3]. However, it should appear at $Fe_{50}Pt_{50}$ (stoichiometric composition of $L1_0$- FePt alloy). Therefore, it is considered that Fe is effectively decreased and we assume the existence of Fe dead layer. For reduction a factor of the oxygen in the interface of Fe- SiO_x, we inserted a silicon nitride (SiN) layer between Fe and SiO_x layer. The Saturation Magnetization (M_s) of the sample on SiN increased more than 3 times in comparison with M_s of the sample on SiO_x.

１．Introduction

We have investigated the formation of $L1_0$- FePt grains for the high density magnetic recording media and it has been reported that isolated $L1_0$- FePt nano grains were fabricated by Rapid Thermal Annealing (RTA) and Rapid Cooling Process (RCP) for Pt/ Fe multilayered thin films on thermally oxidized Si (SiO_x) sub. [1, 2]. In the case of total film thickness of initial deposited Pt/ Fe is 1.88 nm, the coercive force of formed FePt grains considerably depends on the composition ratio of Pt/ Fe film and the coercive force is 42 kOe as maximum at $Fe_{62}Pt_{38}$[3]. However, the composition ratio of $L1_0$- FePt alloy is $Fe_{50}Pt_{50}$ and appear high coercive force at $Fe_{50}Pt_{50}$. Therefore, it is considered that the effective composition ratio of the Fe decreased and we assume the existence of Fe dead layer. The effective composition ratio shifts more at ultra-thin Pt/ Fe films for formation of high areal density of grains and it is difficult to control the effective composition ratio of FePt. Therefore, we inserted a silicon nitride (SiN) layer between Fe and SiO_x layer for reduction of Fe dead layer. We chose SiN which was not included a factor of the oxidation. A thermal characteristic of SiN was similar to SiO_2, we expect not to change the thermal process in RTA. We evaluated the grains which fabricated by RTA and RCP on SiN using morphologies, crystalline structures and magnetic properties.

２．Experimental condition

Pt/ Fe/ SiN films on flat thermally oxidized Si (SiO_x) sub. was deposited by DC·RF magnetron sputtering. Total film thickness of initial deposited Pt/ Fe was 1.88 nm and the composition ratio was $Fe_{50}Pt_{50}$. We changed the film thickness of SiN (t = 0, 5, 20 nm). We showed the film designs of each sample in Fig. 1. These samples were annealed by RTA (maximum temperature: about 700 ℃, heating rate: about 170 ℃/s.) in a vacuum chamber at 1.0×10^{-3} Pa. When the maximum temperature, N_2 gas was flowed for RCP (cooling rate: about - 85 ℃/s.). The morphologies of each sample were observed by Scanning Electron Microscope (SEM). The crystal structures were analyzed by X-ray Diffraction (XRD). Magnetization vs. Magnetic field (M-H) loops were evaluated by Superconducting Quantum Interference Device - Vibrating Sample Magnetometer (SQUID - VSM).

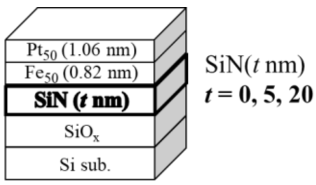
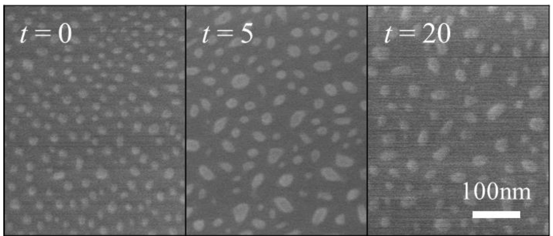


Fig.1 Film designs of each sample.



D_a: 17.7	D_a: 23.7	D_a: 22.2
S_tD: 2.76	S_tD: 5.27	S_tD: 5.48
N_p: 0.57	N_p: 0.31	N_p: 0.37

Fig.2 SEM images of each sample, average diameter of grains (D_a) nm, standard deviation of diameter (S_tD) nm and areal density of grains (N_p) T particles/ inch^2.

３．The morphologies

The morphologies of fabricated isolated grains and average diameter of grains (D_a), standard deviation of diameter (S_tD) and areal density of grains (N_p) were shown in Fig. 2. In comparison with isolated grains on SiO_x, D_a and S_tD of grains on SiN increased and N_p decreased. When t = 5, 20, we showed approximately equal morphologies of grains, D_a, N_p and S_tD. It is considered that the formation of the grains on SiN changed Because

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interfacial state and mobility in the grains formation process changed.

4. The crystalline structures

The X-ray diffraction pattern of each sample were shown in Fig. 4. The XRD peak of these sample (t = 0, 5, 20) was observed around 2θ of $L1_0$- FePt(111). The XRD peak of the sample shifted to 2θ of $L1_0$- FePt(111) by inserting SiN layer. It is considered that the component of $L1_0$- FePt(111) increased by inserting SiN layer.

5. The magnetic properties

Out-of-plane M - H loops of each sample at 300K were shown in Fig. 3. The magnetic properties of the sample on SiN showed the high coercive force and when t = 5, value of coercive force was maximum about 10 kOe. The Saturation Magnetization (M_s) of the sample on SiN increased more than 3 times in comparison with M_s of the sample on SiO_x. It is considered that the Fe dead layer decreases and $L1_0$- FePt layer increased by inserting SiN layer between Fe and SiO_x layer and depends on the composition dependence on SiO_x was affected by oxygen in the interface of Fe- SiO_x.

We fabricated grains by RTA and RCP for Pt/ Fe/ SiN (t = 20nm) on flat thermally oxidized Si (SiO_x) sub.. Total film thickness of initial deposited Pt/ Fe was 1.88 nm and the composition ratio was $Fe_{62}Pt_{38}$. The remanent magnetization and saturation magnetization (M_r/M_s) of sample of $Fe_{50}Pt_{50}$ on SiO_x decreased in comparison with M_r/M_s of the sample of $Fe_{62}Pt_{38}$ on SiO_x [3]. However M_r/M_s of sample of $Fe_{50}Pt_{50}$ on SiN was not almost change M_r/M_s of the sample of $Fe_{62}Pt_{38}$ on SiN.

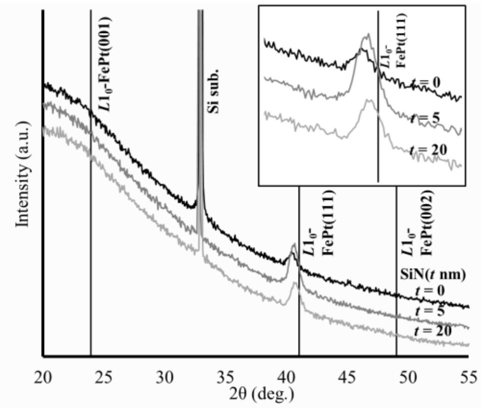

Fig. 3 X-ray Diffraction pattern of each sample.

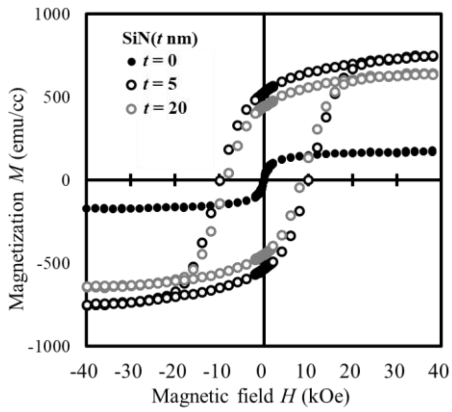

Fig. 4 Out-of-plane M-H loop of each sample at 300K.

6. Conclusion

We aimed at reduction of the Fe dead layer which which does not contribute to the magnetic property in the interface of Fe- SiO_x and we inserted SiN (t = 0, 5, 20 nm) between Fe and SiO_x layer which did not include the oxidation. We fabricated isolated grains on SiN film by RTA and RCP. It is considered that the formation of the grains on SiN changed Because interfacial state and the mobility in the grains formation process changed. The XRD peak of the sample shifted to 2θ of $L1_0$- FePt(111) by inserting SiN layer. H_c, M_s of the sample on SiN increased in comparison with H_c, M_s of the sample on SiO_x. It is considered that the Fe dead layer decreases and $L1_0$- FePt layer increased by inserting SiN layer between Fe and SiO_x layer and we consider the composition dependence on SiO_x which was the effective composition ratio of the Fe decreased was affected by oxygen in the interface of Fe- SiO_x.

7. Acknowledgement

This work is partially supported by Storage Research Consortium and MEXT-Supported Program for the Strategic Research Foundation at Private Universities2013-2017.

8. References

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