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Composition dependence of the formation of monodisperse FePt grain with high-temperature rapid-annealing

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Abstract: We aim to fabricate isolated monodisperse FePt grain array with high coercivity for high density magnetic recording media. We assumed that the volume of prefabricated FePt isolated patterns by electron beam lithography technique was kept during annealing. We expected to be formed $L1_0$-FePt alloys by high-temperature rapid-annealing and FePt grain exhibiting high coercivity with adjust composition ratio of Fe_xPt_{100-x}. In this report, we changed composition ratio Fe_xPt_{100-x} to investigate composition dependence of morphology and magnetic property by high-temperature rapid-annealing. In result, lowest disperse FePt grains with high coercivity were formed in composition of $Fe_{55}Pt_{45}$ at maximum annealing temperature=800℃ and rapid-annealing.

1. Introduction

We aim to fabricate isolated monodisperse FePt grain array with high coercivity for high density magnetic recording media. We reported that isolated $L1_0$-FePt grains were fabricated by Rapid Thermal Annealing (RTA) for Pt/ Fe bilayer thin film on thermally oxidized substrate [1]. In RTA process, morphological changes from continuous thin film to the grain cases non-uniform while separation and integration. We assumed that the volume of prefabricated FePt isolated patterns by electron beam lithography technique was kept during annealing. We expected to be formed $L1_0$-FePt alloys by high-temperature rapid-annealing and FePt grain exhibiting high coercivity with adjust composition ratio of Fe_xPt_{100-x} [2]. In this report, we changed composition ratio Fe_xPt_{100-x} to investigate composition dependence of morphology and magnetic property by high-temperature rapid-annealing.

2. Experimental method

Fig.1 shows fabrication process images. We fabricated FePt isolated patterns by electron beam lithography technique and lift off method. On the thermally oxidized Si substrate coated with 35nm ZEP520A resist. Mask pattern fabricated by electron beam system with 50kV acceleration voltage and development. After this process, by DC magnetron sputtering, Pt_{50}(2.11nm)/ Fe_{50}(1.64nm) bilayer film were fabricated. Pt/ Fe isolated dots with 100nm pitch were fabricated by resist removes. RTA was performed with conditions of maximum annealing temperature : about 800℃, heating rate: about 120 ℃/s. And we changed composition ratio Fe_xPt_{100-x} (x=50,55,57). In order to measure the magnetization curve, we fabricated 256 million of FePt dots in 1.6millimeter square area. Morphology changes were evaluated by SEM (Scanning Electron Microscope), AFM (Atomic Force Microscope) Magnetic property of fabricated isolated FePt grains were evaluated by SQUID-VSM (Superconducting Quantum Interference Device -Vibrating Sample Magnetometer).

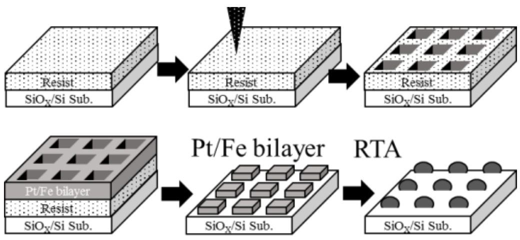

Fig.1 Fabrication process images.

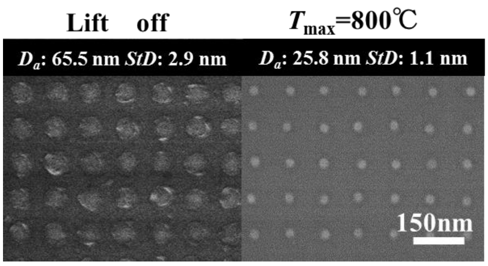

Fig.2 SEM images, grains average diameter (D_a) and standard deviation of D_a (*StD*).

3. Fabrication of FePt grain by high-temperature rapid-annealing

Fig.2 shows the SEM images, grains average diameter (D_a) and standard deviation of D_a (*StD*). Fig.3 shows cross section of AFM images of FePt dots in each sample. Fig.4 shows M-H curves for FePt grains in out-of-plane at 300K. In T_{max}=800℃, grains were formed while holding the arrangement. *StD* does not almost change by performed high-temperature

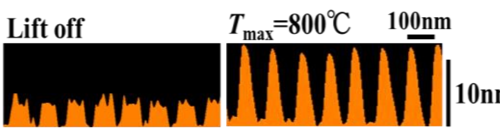

Fig.3 Cross section of AFM images of FePt dots in each sample.

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rapid-annealing. We confirmed decrease in grain diameter and increase in grain height. In T_{max}=800℃, grains are bonded together in the case of thin film. In this process, the in-plane D_a was decreased from 65.5nm to 25.8nm and it grows in the height direction by 300%. Morphology changes was considered by aggregation. Coercivity(Hc) was 20kOe and M_r/M_s (M_r: remanent magnetization, M_s: saturation magnetization) was 0.79. By high-temperature rapid-annealing, alloying was progressed in each FePt grain. FePt grains were formed in approximately 4.4% relative standard deviation. In this fabrication process, expected $L1_0$-FePt type hard magnetic property was appeared in high T_{max}.

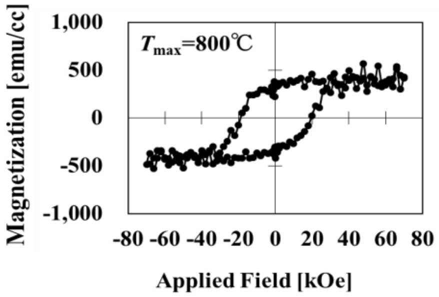

Fig.4 M-H curves for FePt grains in out-of-plane at 300K in each sample.

4. Composition dependency of FePt grain

We changed composition ratio Fe_xPt_{100-x} (x=50,55,57). RTA was performed with conditions of maximum annealing temperature: about 800℃, heating rate: about 120℃/s in each sample. Fig.5 shows the SEM images, grains average diameter (D_a), standard deviation of D_a (StD) and grain size of the histogram in each sample after RTA. Fig.6 shows M-H curves for FePt grains in out-of-plane at 300K. In x=50,55, single grains were formed. FePt grains were formed in approximately 4.4% relative standard deviation. Furthermore, in x=55, Hc=30kOe and M_r/M_s=0.95, higher Hc and M_r/M_s was appeared than x=50. In x=57, dot was separated into several. And width of magnetization switching field was spread. The composition dependence of Pt/ Fe was confirmed in this fabrication process. Lowest disperse FePt grains with high coercivity were formed in composition of $Fe_{55}Pt_{45}$ at maximum annealing temperature=800℃ and rapid-annealing.

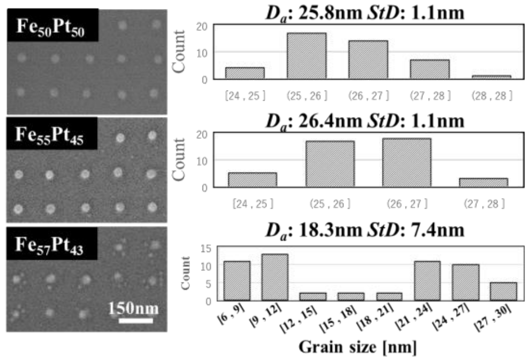

Fig.5 SEM images, grains average diameter (D_a), standard deviation of D_a (StD) and grain size of the histogram in each sample after RTA.

5. Conclusion

We assumed that the volume of prefabricated FePt isolated patterns was kept during high-temperature rapid-annealing. We changed composition ratio Fe_xPt_{100-x} to investigate composition dependence of morphology and magnetic property. In this fabricated process, expected $L1_0$-FePt type hard magnetic property was appeared due to aggregation by high-temperature rapid-annealing. In x=55, Hc was 30kOe. M_r/M_s was 0.95. The composition dependence of Pt/ Fe was confirmed in this fabrication process. Lowest disperse FePt grains with high coercivity were formed in composition of $Fe_{55}Pt_{45}$ at maximum annealing temperature=800℃ and rapid-annealing.

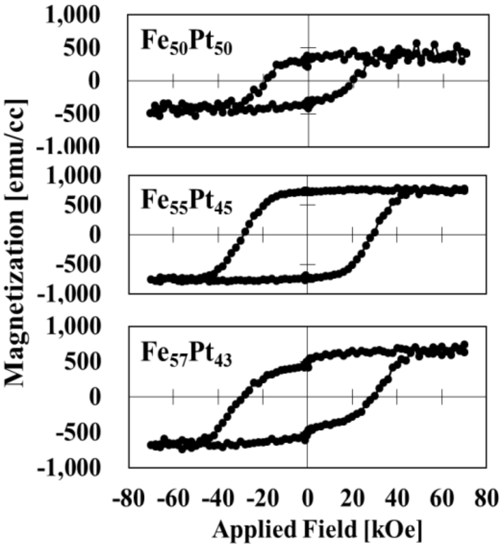

Fig.6 M-H curves for FePt grains in out-of-plane at 300K.

Acknowledgement

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References

[1] A. Itoh, A. Tsukamoto, S. Okame and K. Mizusawa: J. Magn. Soc, 36, 62-65 (2012).

[2] Masayuki Imazato, Aki Ogasaara, and Arata Tsukamoto: MORIS2015, Penang, alaysia, Tu-P-12, (2015).