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Fabrication of surface periodic nano metallic structure on meso-polus SiO_2 substrate and high density isolated FePt grains

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In this report, meso-polus SiO_2 substrate with periodical surface nano-pores are prepared by utilizing self-assembling / self-organizing phenomenon of tri-block copolymer (Nano Dent Arrey: NDA)[1]. Countinuous metallic double layer of Au (2.5 nm) / Fe (1.0 nm) is deposited on the NDA. In order to get isolated Au particles smaller than 10 nm diameter and periodicity of ~ 15 nm, the deposited metallic layer is etched by Ar ion in incident angle of 85° from nomal to the film surface. Fabricated surface periodic nano Au particles have average diameter of ~ 9.5 nm and the periodicity of 12.5 ~ 15.0 nm. Isolated FePt grains are fabricated by Rapid Thermal Annealing with rapid cooling process (RTA)[2] on the fabricated surface periodic nano metallic structure. The FePt grains have average grain diameter D_a = ~ 7.63 nm, areal density of particles N_p = 3.82 T particles / inch^2, standard deviation of D_a S_D = 1.37 nm. On the other hand, in the case of FePt grains fabrication on flat thermally oxidized Si substrate, the grains have D_a = ~ 14.1 nm, N_p = 0.76 T particles / inch^2 and S_D = 2.48 nm. Thus, fabricated FePt grains on surface periodic nano metallic structure are decreased ΔD_a = ~ 6.5 nm, increased ΔN_p = 3.06 T particles / inch^2 and decreased ΔS_D = 1.11 nm comparing with fabricated on flat thermally oxidized Si substrate.

1. Introduction

The idea of this study could achive to get small FePt grains less than 10 nm and high density grains to several T particles / inch^2 for the purpose as Bit Patterned Media of ultra high density recording media. We reported that meso-polus SiO_2 substrate with periodical surface nano-pores were prepared by utilizing self-assembling / self-organizing phenomenon of tri-block copolymer (NDA), And showed possibility of leading fabricated potision of FePt grains on filling middle of particles with Au structure in fabricated self assembled nano-sillica particles by defference of surface enegy between Au and SiO_2[3]. In this report, We fabricate surface nano periodic Au particles structure utilizing method of Ar ion Dry Etching to deposited continuous Au / Fe double layer on NDA in incident angle of 85° from nomal to the film surface. The structure has small diameter less than 10 nm and periodycity of ~ 12 nm utilized periodical structure of NDA. We fabricate high density FePt several nm grains on surface nano periodic metallic structure and flat thermally oxidized Si substrate as reference structure.

2. Fabrication of NDA

Surface nano periodic metallic structure is fabricated utilized NDA. Thus, surtface nano periodic metallic structure depends on periodic structure of NDA. In order to form preiodicity of ~ 12 nm nano-pores, molecular weight of a tri-block copolymer is used 8400 g / mol. Transmission Electron Microscope: TEM planer view images of Fabricated NDA is shown in Figure 1. The meso-polus SiO_2 substrate film is consisted from face-center-cubic lattice. The periodicity of pores is approximately 11.2 ~ 14.0 nm, in Figure 1.

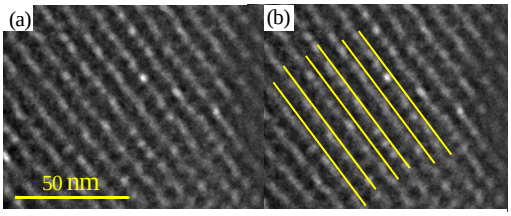

Figure 1 TEM planer view images of NDA (b) guide to eye. (a), (b) are similler images.

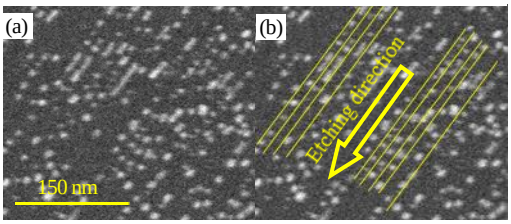

Figure 2 SEM planer view images of etched Au / Fe / NDA thin film (b) guide to eye. (a), (b) are similler images.

3. Ar ion Dry Etching for Au layer on NDA

Countious metallic double layer of Au (2.5 nm) / Fe (1.0 nm) is deposited on the NDA using DC magnetrin sputtering. The thin film is obsereved uniform surface structure by Scaning Electron Microscope: SEM and Atomic Force Microscope: AFM. The deposited metallic layer is etched by Ar ion in incident angle 85° from vertical line to thin film. The etching gas is

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Ar ion, the acceleration voltage is 500 V, the incident ion electric current density is 1.5 mA / cm^2 and the etching time is 75 sec. The images of SEM planer view, TEM planer view, and electron beam diffraction view were shown Figures 2,3(a) ~ (c). The average periodicity of Au particles in a domain of reflect periodic NDA structure is approximately 12.5 ~ 15 nm cearly the peridodic structure depend on etching direction and periodic structure of NDA. Crystallographic structure is observed by electron beam diffraction in only black region of Figure 3 (a), as in Figure 3 (b). Non-crystalline structure region is confiremed by observation of electron beam diffraction in only white region of Figure 3 (a), as in Figure 3 (c). As a result the fabricated surface structure consist from metallic particles and non-crystalline SiO_2 region.

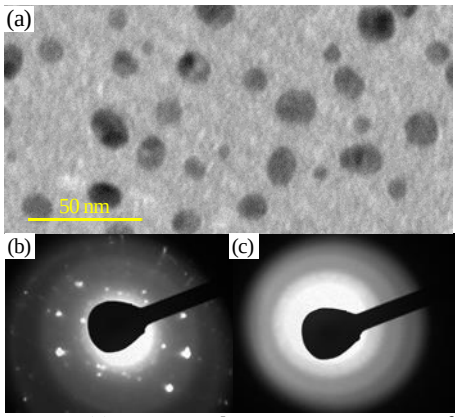

Figure 3 (a): TEM planer view image of fabricated surface nano metallic structure. (b): Electron beam diffraction image in only black region. (c): Electron beam diffraction image in only white region.

4. Fabrication of isolated FePt grains

To get smaller isolated FePt grains and higher density grains, FePt grains are fablicated on (A): surface nano periodic metallic structure, (B): flat thermally oxidized Si substrate as reference. Pt (1.05 nm) / Fe (0.83 nm) double layer deposited on sub using DC Magnetron Sputtering. The composition of the films are $Fe_{50}Pt_{50}$. At first, substructure is used (A): surface nano periodic metallic structure, Isolated FePt grains are fabricated by RTA at the heating rate T_R = 107 ℃ / s and the maximum temperature T_m = 406 ℃ for continuous double films shown in Figure 4 (a). D_a = ~7.63 nm, N_p = 3.82 T particles / $inch^2$, S_D = 1.37 nm. At second, substrate is used (B): flat thermally oxidized Si substrate, FePt grains is fabricated by RTA at the T_R = 112℃ / s and the T_m = 672 ℃ for continuous double films shown in Figure 4 (b), D_a =14.1 nm, the N_p = 0.76 T particles / $inch^2$ and the S_D = 2.48 nm. Therefore, fabricated FePt grains on surface nano structure make ΔD_a decrease ~ 6.5 nm, ΔN_p increase 3.06 T particles / $inch^2$ and ΔS_D decrease 1.11 nm comparing with fabricated on flat thermally oxidized Si substrate.

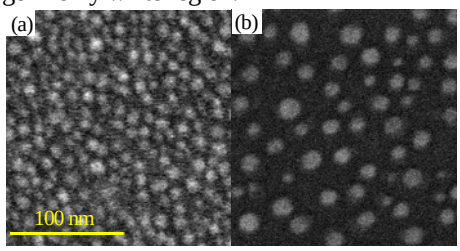

Figure 4 (a): SEM planer view image of isolated FePt grains on surface nano metallic structure (b): on flat thermally flat oxidized Si substrate.

5. Conclusion

We fabricate surface nano metallic structure by utilized NDA having the average periodicity of pores approximately 11.2~14.0 nm. The structure consist on metallic particles on meso-polus SiO_2 that average diameter is approximately 9.5 nm and the average periodicity is 12.5 ~ 15.0 nm. On surface nano metallic structure, fabricated FePt grains have D_a = 7.63 nm, N_p = 3.82 T particles / $inch^2$ and S_D = 1.37 nm. On the other hand, fabricated FePt grains on flat thermally oxidized Si substrate have D_a =14.1 nm, N_p =0.76 T particles / $inch^2$ and S_D = 2.48 nm. Fabricated FePt grains on surface nano structure decrease ΔD_a = ~ 6.5 nm, increase ΔN_p = 3.06 T particles / $inch^2$ and decrease ΔS_D = 1.11 nm comparing with fabricated on flat thermally oxidized Si substrate.

Acknowledge

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