LARGE UNIAXIAL ANISOTROPY $Co_{50}(Pt_{1-x}Rh_x)_{50}$ THIN FILMS FOR MICROWAVE ASSISTED MAGNETIC RECORDING

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Conventional perpendicular magnetic recording (PMR), based on CoCrPt-oxide media, suffers from the problem of thermal stability for the areal densities > 1 Tbpsi [1]. Shingled magnetic recording (SMR) has pushed the areal density limits slightly beyond > 1 Tbpsi. For increasing the areal density beyond 2 Tbpsi, introduction of novel technologies is needed. Microwave assisted magnetic recording (MAMR) is considered as one approach to increase the areal density. Heat-assisted magnetic recording is a potential candidate to increase the areal density ~4 Tbpsi. In comparison to HAMR, which requires many new technologies, MAMR requires only minor improvements to be adopted. MAMR media need to possess a higher anisotropy than the PMR media. In this sense, equiatomic CoPt magnetic alloys with a higher Pt than that of PMR media candidates are promising. In the ordered $L1_0$ and $L1_1$ phase, they exhibit a high anisotropy (~10^7 erg/cc) but they require a high temperature fabrication process. In the HCP-phase also, which can be fabricated at room temperature, they exhibit a high anisotropy. However, at equiatomic compositions, it is difficult to grow thick HCP-CoPt without forming low anisotropy FCC phase [2]. One way to avoid this problem is partial replacement of Pt by Rh [3]. However, in the absence of a segregant, these films have a low coercivity due to the exchange coupling between the grains. In this study, we have investigated the effect of patterning on such films, in order to see if a high coercivity can be obtained in these films by decoupling the magnetic switching units.

Film stacks of the type “C (7 nm)/ $Co_{50}(Pt_{1-x}Rh_x)_{50}$ (20 nm)/ Ru (20 nm)/ Pt (6 nm)/ Ta (5 nm)/ Glass substrate” were deposited using dc magnetron sputtering. After depositing the film stack, a mask pattern was fabricated using self-assembly of PS (polystyrene)-PDMS (polydimethylsiloxane) di-block copolymers (DBCP). Molecular weight of PS-PDMS DBCP used for this purpose was 54 kg/mol with 22% weight fraction of PDMS. Figure 1(a) shows the schematic of film stack with DBCP self-assembly. It should be noted that the dotted mask pattern is made of PDMS/SiO_2 on the PS column. Figure 1(b) shows the AFM image of the mask pattern on $Co_{50}(Pt_{1-x}Rh_x)_{50}$ films. AFM images were obtained by scanning the sample area of 2 µm × 2 µm.

Figure 1 (c) shows the XRD patterns of $Co_{50}(Pt_{1-x}Rh_x)_{50}$ samples. As the Pt concentration decreases, Co (001) peak shifts towards high 2θ values, approaching the peak positions typically observed in PMR media. The hysteresis loops indicate a perpendicular magnetic anisotropy (PMA), only for x=0.4 and beyond. Magnetic force microscopy (MFM) measurements show stark contrast in domain patterns around x= 0.4, indicating a higher PMA at this composition range. Torque measurements indicate a higher anisotropy constant for samples with x = 0.4 to x = 0.6. Observed increase in K_u is explained to be arising due to improvement in HCP stacking. With further increase in Rh content, decrease in K_u is due to decrease in orbital magnetic moment and the spin–orbit coupling as Rh has the smaller spin–orbit coupling constant compared to Pt.

After successfully creating the dot pattern on the magnetic $Co_{50}(Pt_{1-x}Rh_x)_{50}$ films, we transferred the pattern to the magnetic layers through three step reactive ion etching and one step Ar ion milling process. The effect of patterning can clearly be seen from the hysteresis loops and MFM domain maps. MFM domain maps were measured on 5 µm × 5 µm sample area. No magnetic field was applied during the measurements. The presence of dotted domain patterns confirms the patterning of the samples. At the same time, the magnetization (emu/cc) of the samples has also decreased, which is another evidence of the effect of patterning of the samples. While the coercivity did not change much for the samples with a lower anisotropy, for the samples with higher perpendicular anisotropy, the coercivity was found to increase. This increased coercivity suggests a decrease in exchange coupling. The measurements of H_c at different angles

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also confirm a change in reversal mechanism from “domain wall motion” to coherent rotation. However, the increase in coercivity observed with a patterning process is not significantly high. Therefore, alternative methods to increase the coercivity in these films are desired.

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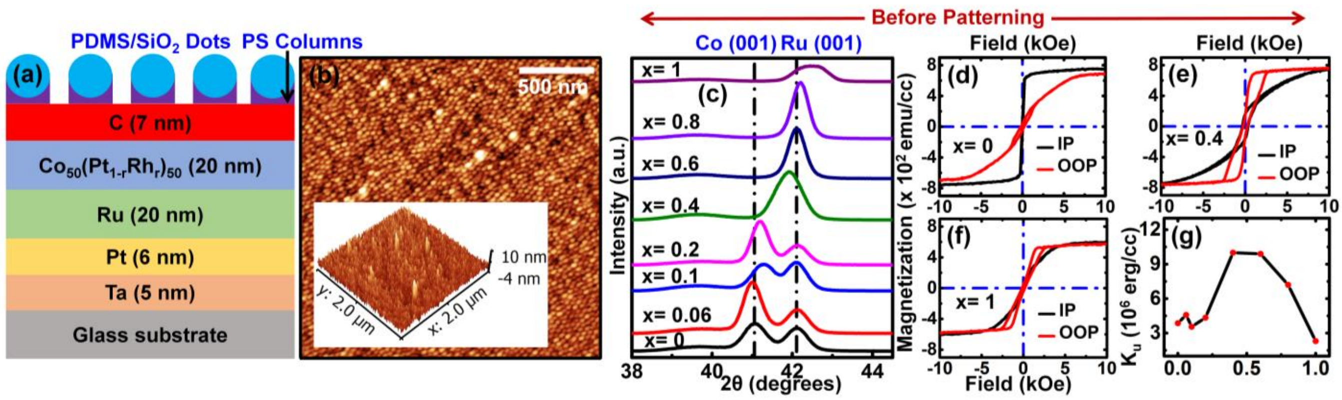

Fig. 1. (a) Schematic of the film stack and dot pattern of PDMS/SiO_2 on magnetic film stack, (b) AFM image of the dot pattern on magnetic films (inset: 3D image of dot pattern), (c) XRD patterns of $Co_{50}(Pt_{1-x}Rh_x)_{50}$ samples, (d)-(f) Hysteresis loops of $Co_{50}(Pt_{1-x}Rh_x)_{50}$ samples with x= 0, 0.4 and 1 and (g) variation of anisotropy constant for different x, measured using Torque Magnetometry.

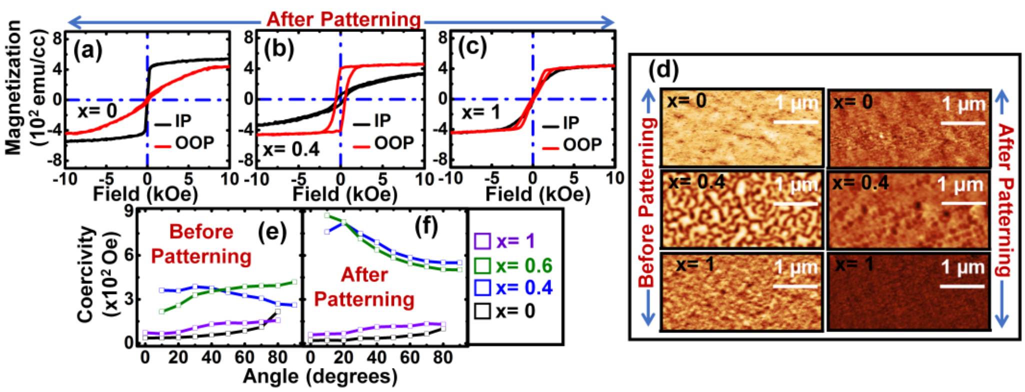

Fig. 2. (a)-(c) Hysteresis loops of patterned $Co_{50}(Pt_{1-x}Rh_x)_{50}$ samples with x= 0, 0.4 and 1, (d) MFM domain maps of $Co_{50}(Pt_{1-x}Rh_x)_{50}$ samples with x = 0 (extreme top), 0.4 (middle), 1(extreme bottom), (e) Angle dependent coercivity of un-patterned and (f) patterned $Co_{50}(Pt_{1-x}Rh_x)_{50}$ samples with x= 0, 0.4, 0.6 and 1.