Low Temperature Ordering and Media Design of L1₀ Fe-Pt Thin Film for Ultra-High Density Perpendicular Recording

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Introduction

An areal recording density by a current perpendicular recording on a nano-granular CoPtCr-SiO₂ medium is approaching 200 Gbit/in². However, it becomes harder for the granular media to fulfill all requirements, i.e. lower media noise properties, sufficient thermal stabilities of recorded bits and writabilities for high recording resolutions. On the other hand, we proposed a pinning type Fe-Pt medium with the thermal stability and the writability with a high recording resolution [1], which came from the principle of perpendicular magnetic recording characterized by demagnetizing field-free transitions [2]. In this paper, the low temperature ordering and design for L₁₀ Fe-Pt perpendicular recording media are discussed.

Low temperature ordering for Fe-Pt(001) thin films

Ordered Fe-Pt thin films with perpendicular magnetic anisotropy were so far prepared at temperatures over 500°C using a single crystal MgO substrate by various deposition methods [3-9]. On the other hand, we prepared the Fe-Pt(001) thin film on a glass disk substrate for the first time [10], proposed both a hetero-epitaxial layer configuration of Fe-Pt/Cr/MgO/Glass-substrate and a high pressure sputter-deposition method [11]. As shown in Fig. 1, a deposition condition of 50 Pa leads to a sufficient large perpendicular coercivity even at the temperature of around 300°C, that is 150°C lower than that of 5 Pa condition. By in-plane and out-of-plane XRD measurements for the films deposited at 50°C, a disordered phase by the 50 Pa condition was found to be of a crystal structure with a lattice aspect ratio of d(001)/d(100)<1, that was close to the fct phase [12]. Thus, the low temperature ordering by the high pressure deposition comes from a strain-induced preferred phase transformation [11]. Furthermore, material requirements for pinning type media with small domain sizes were considered based on the domain theory and the pinning type Fe-Pt film was also presented by the high pressure sputter-deposition method [12,13].

Design of double-layered perpendicular Fe-Pt media

A double-layered construction for perpendicular Fe-Pt media was first designed, using a hetero-epitaxial configuration with an Fe-Si soft-magnetic underlayer (SUL) and an MgO intermediate layer, as shown in Fig. 2 [14]. The very thin MgO(100) intermediate layer of 1 nm on the Fe-Si(100) SUL had good effects on not only improving a crystallinity of an initial growth layer in the Fe-Pt(001) but also elimination of an interlayer exchange-coupling between the Fe-Pt and Fe-Si layers.

The effect of the domain sizes on SNR of Fe-Pt double-layered media with Hc of 3 kOe-5 kOe is summarized in Fig. 3 [12]. Except for the (Fe-Pt)-SiO₂ medium, the SNR was improved with reduction of the domain size, thus, the highest SNR was obtained by the Fe-Pt with many crystal defects induced by two-step deposition method [15]. This is because the media noise is suppressed with the smaller domain restricted by the defects. On the other hand, the lowest SNR of the (Fe-Pt)-SiO₂ medium was due to a smallest signal output that resulted from an unsaturated recorded state. Therefore, the coexistence of both the smaller domain and the saturation-recording condition should be needed for the higher SNR.

Recently, we have reported an Fe based amorphous SUL with a Mn-Ir biasing layer [16]. While application of the new SUL to Fe-Pt media required a thicker MgO intermediate layer of 5 nm, the medium with the SUL of a radial anisotropy was found to show a further high SNR [17]. This means that suppressing the fluctuation of writing field gradient, dH/dx, is more important for the pinning type Fe-Pt media to achieve higher SNR.

Possibility for ultra-high density recording

Based on a reproducing theory [18], thinner recording layers and higher recording resolutions (πα) lead to higher reproducing resolutions. A 5 nm thick Fe-Pt pinning type medium was confirmed with the sufficient thermal stability [14]. In addition, a large loop slope parameter, α, of this type can produce the high writability for the high recording resolution [19]. Therefore, the Fe-Pt medium would be expected to show a high reproducing resolution. Figure 4 shows transition widths of reproducing waveform, T₅₀, for the Fe-Pt of 7.5 nm and Co-Cr-Nb-Pt medium of 50 nm. The Fe-Pt medium exhibited a narrow T₅₀ value of 22 nm by applying the GMR reproducing head with shield gap length of 92 nm. Judging from the agreement with the calculated one [18], this high reproducing resolution is due to the thinner recording layer of Fe-Pt. Moreover, further high resolutions can be expected for the ultra-thin Fe-Pt medium by applying further narrow shield gap GMR reproducing heads. Thus, it is safe to conclude that the
pinned type ultra-thin Fe-Pt medium has a high potential as a future ultra-high density recording medium.

**Conclusions**

The pinned type perpendicular media design is a hopeful concept for an ultra-high density recording medium to achieve both the sufficient thermal stability and the writability with high recording resolution. Furthermore, a higher SNR will be achieved by comprehension and tailoring of the pinning sites in the ultra-thin Fe-Pt film.

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**References**


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**Fig. 1.** Effect of sputtering pressures on perpendicular Hc.

**Fig. 2.** Fe-Pt perpendicular double-layered construction.

**Fig. 3.** Relationship between domain sizes and SNR.

**Fig. 4.** Effect of shield gap lengths of GMR readers on T50.