The Crystallographic and Magnetic Properties of $Fe_{3-x}M_xO_4$ (M=Ni, Zn) Magnetic Films prepared by Spin-Spray Ferrite Plating Method

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Abstract—In order to develop good backlayer for the Co-Cr perpendicular magnetic recording media, crystalline films of spinel, (Fe, M) $_3O_4$ (M=Ni and Zn) were prepared on glass substrates by spin-spray ferrite plating method. Reaction and oxidizing solution were sprayed in the reaction chamber in which the substrate is rotating. The reaction was influenced by concentration of reaction solution (R_c) and oxidizing solution (O_c), the flow rates of the reaction solution (R_f) and oxidizing solution (O_f), reaction temperature (T) and rotation speed of substrate (S_r). Under the condition where $R_f, O_f=60$ [ml/min], $T=90$ [°C] and $S_r=150$ [rpm], effect of R_c and O_c on the ferrite plating reaction were studied in aspect of chemical composition, crystallographic and magnetic properties. In the composition of $Ni_{0.34}Zn_{0.66}Fe_2O_4$, we have the stable crystallographic and magnetic properties.

I. INTRODUCTION

There are several methods to perform ferrite plating to prepare the films with crystalline spinel structure in an aqueous solution at low temperature (< 90 °C) [1,2]. Among them, "Spin-spray" method, in which a reaction solution and oxidizing solution are simultaneously sprayed onto a spinning substrate which is kept at 90 [°C], is the most excellent technique for getting good quality films [3].

Ferrite films prepared in this method will be used of backlayer under Co-Cr films for inhabitation eddy current loss and improvement the high frequency properties of Co-Cr perpendicular magnetic recording media.

Previously, the same process of the aspect using ferrite single-crystal substrate was studied, but we consider that using ferrite film is desirable from the practical view.

In this paper, we report the crystallographic and magnetic properties of the Ni-Zn ferrite films which are deposited for spin-spray ferrite plating method.

II. EXPERIMENTAL METHOD

The ferrite plating was performed by spin-spray method on glass substrates [4,5]. We used a reaction solution (pH=5.2) which contains $FeCl_2 \cdot 4H_2O$, $NiCl_2 \cdot 6H_2O$ and $ZnCl_2$ and an oxidizing solution (pH=6.9) which contains $NaNO_2$ and CH_3COONH_4 , simultaneously sprayed these two solutions for 30 min. The substrate was kept at 90 [°C] and spun at 150rpm during plating.

We have performed magnetic properties (perpendicular to film plane) using VSM and crystallographic properties using XRD. The surface and thickness in each layer were observed and measured by AFM and SEM, respectively. Also, the chemical composition of samples plated on the substrates were analyzed by ICP.

III. RESULTS AND CONCLUSION

Table 1. Various characteristics of Ni-Zn ferrite films prepared with various of reaction solution and oxidizing solution.

Sample	Fe [mmol/ℓ]	Ni [mmol/ℓ]	Zn [mmol/ℓ]	$NaNO_2$ [mmol/ℓ]	CH_3COONH_4 [mmol/ℓ]
A	7.6	6.3	0.37	3.6	65
B	7.6	6.3	0.74	3.6	65
C	7.6	4.2	0.74	6.2	65
Sample	Chemical Composition	Size of Grain [nm]	Thickness of Layer [μm]	$H_c \perp [Oe]$	Crystallinity of Layer
A	a)	180	0.25	25.7	Good
B	b)	1500	1.00	50.2	Poor
C	c)	370	0.12	19.5	Poor

a) : $(Ni_{0.34}Zn_{0.66})Fe_2O_4$

b) : $(Ni_{0.24}Zn_{0.76}Fe_{0.06})Fe_2O_4$

c) : $(Ni_{0.31}Zn_{0.4}Fe_{0.29})Fe_2O_4$

The table 1 is the various characteristics of Ni-Zn ferrite films prepared at various content of reaction solution and oxidizing solution.

Fig. 1 X-ray diffraction diagrams of sample A.

Fig. 2 SEM photographs of cross area of sample A.

Fig. 3 AFM image within surface area of sample A.

Fig. 4 AFM image within surface area of sample B.

The sample B is strong for coercive force, however, the thickness of the film is too thick and crystallinity is bad with several grains heavily massed each other.(Fig. 4)

Fig. 5 AFM image within surface area of sample C.

Being seen that sample C is very weak for coercive force and crystallinity is bad, resulting from massed grain,(Fig. 5) so sample B and C is unsuitable for the backlayer of Co-Cr perpendicular magnetic recording media.

On the other hand, sample A is good for the crystallinity(Fig. 1) and surface condition of film, the thickness is adequate as about $0.25[\mu\text{m}]$, (Fig. 2) the grain isolation is clear, (Fig. 3) and the size of particle is very fine.

Sputter deposition of Co-Cr is far more affected over morphology surface than being affected by crystalline of Ni-Zn ferrite backlayer.

As shown in Table 1, since the size of grain and the isolation cause difference of perpendicular magnetic force, we consider that sample A with very fine grains and excellent flat surface appearance is more suitable as its

backlayer.

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