PREPARATION AND CHARACTERISTICS OF Co-ADSORBED IRON OXIDE LIPS TAPE

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Abstracts--- LIPS (Longitudinally oriented Inside layer and Perpendicularly oriented at Surface layer) tapes were prepared using a conventional Co-adsorbed γ -Fe₂O₃ pigment (Hc ~ 650 Oe). TEM photo of cross sectional slice shows parallel oblique orientation structure nearly in full thickness with an average tilt angle of ca.45 degrees, for the most perpendicularly oriented specimen (SQRz~0.66, SQRx~0.64). Its recording characteristics showed difference between tape transport directions as in a ME tape. In its good direction higher density character was achieved comparing with a longitudinal tape; 3.9 dB higher at a wave length of 0.6 μ m.

INTRODUCTION

In the previous paper [1] we prepared a metal LIPS tape having high density and output characteristics by a novel orienting process consisting of advance longitudinal field (AL) --- perpendicular rotation f. (PR) --- perpendicular holding f. during surface air dry (PH-SAD) --- erasing f. (E) --- leveling --- longitudinal f. for inside layer reorientation (LI) --- air dry in full thickness. In this paper we have applied this method to the most popular video pigment (Co- γ Fe₂O₃ of Hc~650 Oe) for the following purposes : 1) Improvement to higher band use without sacrificing long wavelength characteristics and without using special high Hc (~900 Oe) pigment. (Possible practical uses will be for S-VHS-HiFi tape and its magnetic contact print slave tape). 2) Basic understanding on the LIPS medium, which works as perpendicular medium at short wavelengths and works as longitudinal medium showing high output in long wavelengths [2], by considering relationship among the preparation method, R/W characteristics and TEM cross sectional view. For the latter purpose the Co- γ Fe₂O₃ is preferable to the metal due to its deeper recording zone in its tape than in the metal tape with much higher Hc.

In this experiment higher perpendicular orientation has been improved for high density character, however, the ideal LIPS (double layer) orientation tape, in which longitudinal orientation in inside layer coexists, has been difficult to realize at present. In fact a tape with parallel oblique orientation nearly in full thickness was prepared. Its performance, as an intermediate medium of a perpendicular and a longitudinal medium will be described.

EXPERIMENTAL

Dispersion

Co-adsorbed γ -Fe₂O₃ particle : size 0.5-0.7 μ m, aspect ratio~8/1-9/1, σ_s ~78.5 emu/g, Hc~650 Oe. Conventional magnetic dispersion was coated onto a PET film attached on a long (80cm) glass plate with a hand applicator with a 45 μ m clearance. The plate passes through the following magnetic orientation process. Tapes for wavelength response measurement were calendered. The film thickness was about 5.0 μ m.

Magnetic orientation process

The orienting process line is almost the same as that of the previous paper.

Differences are 1) lower field strengths due to lower coercivity of the Co- γ Fe₂O₃ particles and 2) enough perpendicular orientation holding (PH-SAD) to prevent shrinkage redisorientation; for that in addition to the surface air dry a far-infrared plate heater was attached on the pole face. Magnetic fields for each step were produced by pairs of permanent magnets. Their field strength and length are as follows: AL(0.9 kOe, 5cm),PR(2.5 kOe, 15cm),PH-SAD(1.9-1.2 kOe, 15cm),E(- 1.4 kOe,2.5cm),LI(1.1 kOe,5cm). SAD: 1m³/min max and far-infrared radiation(FIR) plate heater : 100Wx2 max. Coating speed: 3cm/s and 1cm/s.

EXPERIMENTAL RESULTS AND DISCUSSION

Magnetic properties

Magnetic data and surface smoothness (or roughness) are shown in Table 1. Perpendicular orientation degree,

appearing as SQRz, in LIPS tapes was increased by intensifying the SAD condition (: increasing air flow rate and FIR heater power) in the order of the LIPS tape number (1-5).

In spite of the increased perpendicular orientation little difference in surface roughness Ra was observed among them. Calendering causes appreciable surface smoothing but inevitable redisorientation (decrease of SQRz and increase of SQRx). Figure 1 shows remanence and coercivity versus angle for 5-LIPS, 6-RANDOM and 7-LONGI.. The tilt angle of the easy axis direction, estimated from the remanence curve, is about 10 degrees relative to the film plane for the 5-LIPS ; this angle is much smaller than the average tilt angle of the particles as seen in the next Fig.2-(a).

Table 1. Magnetic and surface smoothness data.

Before and after calendering (upper and lower row respectively).

Specimen No.	SAD	SQR				Hc[kOe]			Gloss	Ra [nm]
		X	Y	Z	Z*	X	Y	Z		
1 LIPS	<div>weak</div> <div>↓</div> <div>intense</div>	0.83	0.38	0.15	0.37	700	480	430	33	118
		0.83	0.40	0.14	0.35	670	470	400	130	42
2 LIPS		0.81	0.41	0.17	0.39	690	520	480	55	80
		0.81	0.42	0.15	0.44	670	510	450	135	48
3 LIPS		0.78	0.41	0.17	0.51	680	520	490	54	109
		0.77	0.44	0.16	0.44	660	530	450	127	64
4 LIPS		0.72	0.42	0.19	0.53	650	520	500	40	131
		0.73	0.44	0.18	0.49	630	520	490	140	53
5 LIPS		0.57	0.45	0.30	0.73	610	560	610	43	152
		0.64	0.48	0.23	0.66	600	530	570	134	56
6 RANDOM		0.67	0.55	0.18	0.63	650	600	490	43	121
		0.69	0.56	0.16	0.55	630	580	460	129	51
7 LONGI.		0.81	0.39	0.15	0.37	680	490	440	35	128
		0.82	0.40	0.14	0.35	660	480	410	137	48

* : demagnetization corrected

Fig.1 Remanence and coercivity versus angle.

Particle orientation structure by TEM and SEM observation

The magnetic data show only average orientation structure in full thickness. In order to see variation of particle-tilt-angle in depth direction in the LIPS tapes, TEM photographs of cross sectional slices were taken as shown in Fig.2. The side view of 5-LIPS (Fig.2-(a)) shows oblique particle orientation with high vertical component: average tilt angle of about 45 degrees relative to the tape plane. That of 7-LONGI. tape is shown for comparison (Fig.2-(b)). The 3-LIPS tape, which was prepared through weaker surface air dry process comparing with the 5-LIPS, shows double layer like LIPS structure to some extent, though its perpendicular orientation in surface layer is poor.

Surface orientations were also observed by SEM photographs on surface as shown in Fig. 3 , which correspond to the surface layer structure seen in the TEM side views in Fig.2.

(a) 5-LIPS

(b) 7-LONGI.

(c) 3-LIPS

Fig.2 TEM photographs of cross sectional slices.

(a) 5-LIPS

(b) 7-LONGI.

(c) 3-LIPS

Fig.3 SEM photographs on tape surface.

Wavelength response of the tapes

5-LIPS, 6-RANDOM, and 7-LONGI. were measured with a spectrum analyzer and a rotating drum tester having a VHS ferrite head ($g \sim 0.4 \mu\text{m}$) outside. As shown in Fig.4, in short wavelength region below a cross point of $2 \mu\text{m}$, the LIPS tape shows higher output than the longitudinal tape; by 3.9 dB at $\lambda \sim 0.6 \mu\text{m}$. C/N of the LIPS is 27dB at $\lambda \sim 0.6 \mu\text{m}$ as shown in Fig.5. The 6-RANDOM tape also shows higher output than the longitudinal perhaps due to its vertical remanence component, however, the LIPS tape is the highest among them. Its highest density characteristics comes not only from the vertical component but also its "parallel" oblique structure, which will be discussed later, as seen in Fig.2 -(a) and Fig.3-(a).

Recording - reproducing characteristics

Dependence of reproduced output on recording current for 5-LIPS, 6-RANDOM and 7-LONGI. tapes at $\lambda \sim 2 \mu\text{m}$ are shown in Fig.6. In the LONGI. and RANDOM tapes thier outputs tend to decrease at high currents, on the contrary this decreasing tendency is much reduced in the LIPS tape with high vertical component, which perhaps prevents rotation mode[3].

Fig.4 Wavelength response.

Fig.5 Noise spectrum of the 5-LIPS tape.
RBW=10 kHz, ST=5 s, VF=100 Hz

Fig.6 Reproduction versus recording current, at 1 MHz.

Fig.7 Wavelength response.
for "A" and "B" direction ;see Fig.8

Fig.8 Mechanics of the "parallel" oblique orientation through the AL-LIPS process, and tape transport direction on head.

A role of the advance longitudinal field for "parallel" oblique orientation

The parallel oblique orientation structure is similar to a tilted columnar structure in a ME tape[4]. In a similar way recording characteristics of the LIPS tape had difference between two tape transport directions on head (Fig.7). Our data shown in Fig.4, Fig.5 and Fig.6 are only about the good direction (A-direction). In A-direction a recording field vector at trailing zone is across the oblique orientation direction.

In the LIPS preparation without surface roughening [5], a magnetic perpendicular orientation process consists of an advance longitudinal field (AL),for decoupling an agglomerate of strongly coupled antiparallel single domain particles, and a perpendicular field for rotating the decoupled particles. In the course of the study it has proved that the AL field also plays a role to orient particles in "parallel" way as illustrated in Fig.8-(a). On the contrary a conventional intense perpendicular field changes the case as shown in Fig.8-(c) (non-parallel orientation with some vertical component).

In order to verify this assumption, polarity of the permanent magnet poles of the AL was intentionally reversed (from "N-N" to "S-S" as shown in Fig.8-(a) and -

(b)). In wavelength response measurement the "S-S" treated tape showed poorer output in short wavelengths than the "N-N" tape, corresponding to its opposite tilt angle (Fig.7-(b)). In fact the "S-S" tape is functionally same as the "N-N" tape which is reversely transported on head.

We would like to emphasize that both the tape with the parallel oblique structure by the AL-LIPS process, and its proper use in good tape transport direction are important for high density recording of "needle" pigment tape.

Conclusion

LIPS tapes were prepared through the LIPS-orientation-process using conventional Co- γ -Fe₂O₃ pigment. One of the LIPS tapes, which has a parallel oblique orientation structure nearly in full thickness with an average tilt angle of ca. 45 degrees, showed higher output in short wavelength region below 2 μ m than the longitudinal tape; by 3.9 dB at $\lambda \sim 0.6\mu$ m.

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