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In order to improve the resolution in the inking of the dots, vertical anisotropy media configuration is applied to magnetography. The magnetization transition zone length between the dot and the nonmagnetized drum is hoped to be shorter than in the longitudinal configuration. Some preliminary inking tests were successfully carried out on plane samples. A specially designed sputtering group was built for the deposition of CoCr layers. The substrates are full-size drums (diameter = 10 cm, length = 40 cm) and the $Co_{80}Cr_{20}$ target is a cylinder (diameter = 20 cm, length = 50 cm) around the drum. In this paper, the first results obtained with this group are described. The dispersion of the properties of the CoCr layer around the drum is less than 10%. The whole incident power range (up to 15 kW) was scanned. The deposition rate continuously increases with increasing incident power (P_w) up to 9 kW. This rate saturates after 9 kW to a value of 20 Å/s. As in the planar diode sputtering system, the vertical anisotropy of CoCr thin films is improved when high P_w values are used. For these reasons, the optimal incident power was determined as 9 kW. These results show, for the first time, that a dry process could be used for the deposition of a magnetographic medium on a drum.

I. INTRODUCTION

Magnetic printing has been thought of[1] and developed[2] a long time ago. A compact magnetographic printer has been developed since 1980. The working elements of the printer are the magnetic drum and the recording head. Both are shown in Fig. 1. The principle of this technology is roughly the same as in magnetic recording.[2] The main elements of the machine are described in Fig. 2. Some years before, the perpendicular (or vertical) magnetic recording had begun to be developed by many laboratories.[3] The most efficient configuration of the vertical recording on rigid disks was found to be the double recording-layer–single-sided monopole-type head couple. This configuration was adapted to magnetography.[4] On the other hand, the most convenient alloy for the vertical magnetic recording medium was found to be the cobalt-chromium alloy. In this paper are described the first results of a new elaboration method of the drum.

II. PLANAR CONFIGURATION EXPERIMENTS

In order to study the behavior of rf diode CoCr thin films, some depositions were carried out on planar samples (Table I). The evolution of magnetic and structural properties with deposition parameters was studied.[5] The four parameters that were studied were the cathode and the bias voltages (V_k and V_b, respectively), the argon pressure (P_{Ar}) and the thickness of the layer (t_{CoCr}). An example of the resulting variations is given on Fig. 3. The three former parameters were then chosen in order to get the highest vertical magnetic anisotropy. Although the optimal thickness was found to be about 1 μm, the thickness was increased to 10 μm for the magnetographic application. The corresponding hysteresis loops are shown in Fig. 4: the vertical magnetic anisotropy is lowered, but it still remains. Then, some encouraging inking tests were carried out which will not be described here.

III. DEPOSITION APPARATUS, PROCESS, AND PROPERTIES

After this first step, a rf sputtering group was specially designed to deposit CoCr thin films on the real working element of the machine, i.e., the full-size drum. The cathode and the drum are water-cooled and the composition of the target is $Co_{80}Cr_{20}$. The schematics of this new sputtering group is represented on Fig. 5 and the main deposition parameters are summarized in the Table I. A cylindrical and removable shield lies between the cathode and the drum dur-

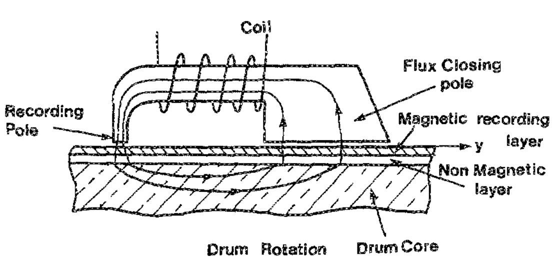

FIG. 1. Head-medium couple for magnetography (Ref. 2).

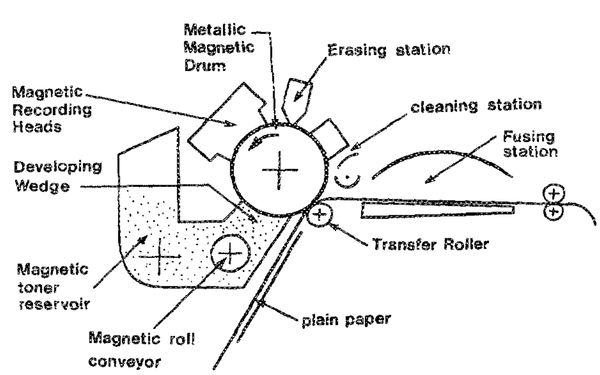

FIG. 2. Magnetographic printer cross section (Ref. 2).

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TABLE I. Deposition conditions in the planar and cylindrical configurations.

		Planar	Cylindrical
Cathode	shape	disk	cylinder
	diameter (cm)	20	20
	length (cm)	···	50
Substrate	shape	disk	cylinder
	diameter (cm)	13	10
	composition	glass	FeNi/Al
Etching of the cathode	incident power P_w (W/cm^2)	2.31	1.43
	Argon pressure P_{Ar} (mTorr)	11.5	10
	operating time t (min)	30	48
	energy $t\times P_w$ (10^9 erg/cm^2)	41.6	41.6
Etching of the substrate	incident power P_w (W/cm^2)	2.31	0.046 ($t=0$)
	Argon pressure P_{Ar} (mTorr)	11.5	100
	operating time t (min)	6	70 (ΔP_w)
	energy $t\times P_w$ (10^9 erg/cm^2)	8.3	8.3
CoCr deposition	incident power P_w (W/cm^2)	3.4	2.4
	Argon pressure P_{Ar} (mTorr)	5	10
	deposition rate R (Å/s)	9.26	9.77

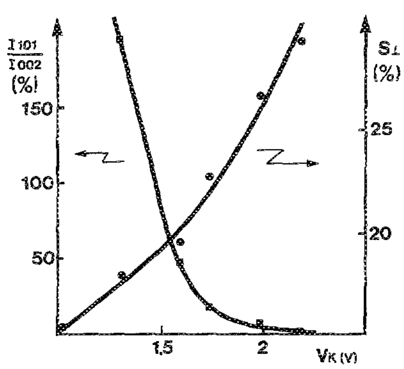

FIG. 3. Perpendicular hysteresis loop squareness ($S_\perp$) and x-ray diffraction ratio I_{101}/I_{002} vs cathode voltage in the planar configuration.

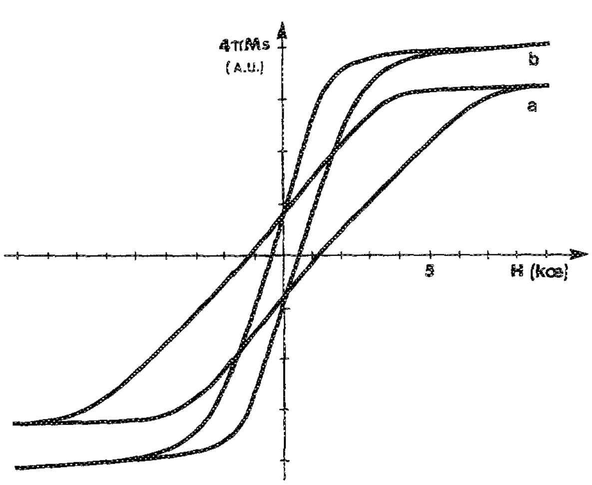

FIG. 4. Perpendicular hysteresis loops of two CoCr layers deposited in the planar configuration with different thicknesses. (a) $t_{CoCr}=1\ \mu$m and (b) $t_{CoCr}=9.8\ \mu$m.

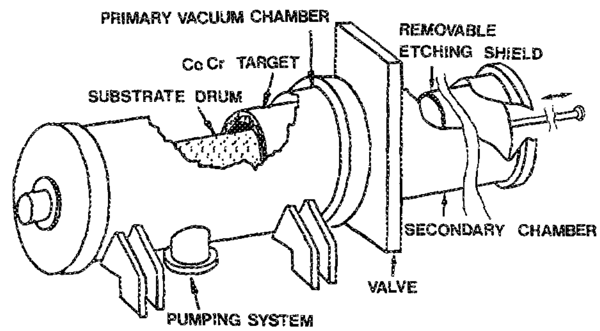

FIG. 5. Scheme of the vacuum chamber for the cylindrical configuration rf sputtering group.

ing the pre-etching of both of them. A rf power supply is used for the pre-etching and the deposition from the cathode and a dc power supply is only used to sputter-etch the drum substrate. Prior to deposition, the vacuum chamber was pumped out until the pressure became lower than 5×10^{-1} Torr. Then the CoCr cathode was pre-etched in the conditions that are described in Table I.

The second step of the process was the dc etching of the drum. The variations of the intensity of the current passing through the plasma when the applied voltage is increased are plotted in Fig. 6 for different P_{Ar}. The variation of the applied power with the etching time is plotted on the Fig. 7. This power obviously stabilizes after 20 min and we think that this time corresponds to the end of the etching of the superficial oxide layer.

The third and last step of the process was the deposition of the CoCr layer. In order to increase the deposition rate (R), we increased the incident power (P_w) from 0 to 15 kW. The relation between these two parameters is represented in Fig. 8. The usual linear relation holds until $P_w=9$ kW; after

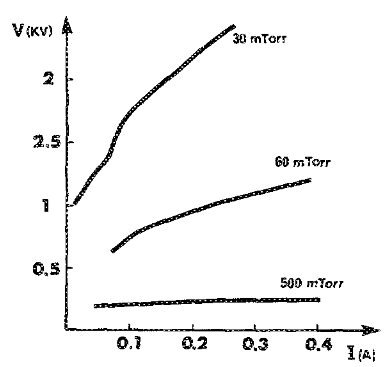

FIG. 6. Variations of the applied voltage (V) vs the current intensity (I) during the pre-etching of the drum for different argon pressures.

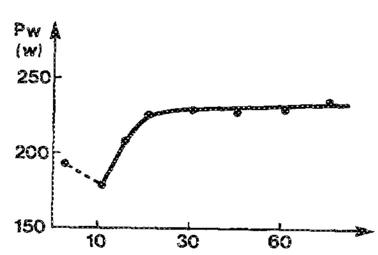

FIG. 7. Evolution of the incident power (P_w) with the etching time of the drum.

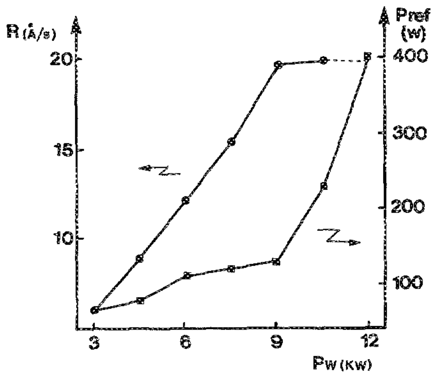

FIG. 8. Deposition rate (R) and reflected power on the drum (P_{ref}) vs incident power (P_w) during the deposition of the CoCr layer.

this value, the deposition rate saturates. Figure 8 also indicates that the reflected power sharply increases after 9 kW; then, thermal losses increase. The optimal value of P_w was chosen as 9 kW.

A typical x-ray diffraction diagram is shown in Fig. 9. Although this layer is structurally well oriented, its magnetic properties do not reveal a vertical orientation. The corresponding vibrating-sample magnetometer (VSM) hysteresis loops are represented in Fig. 10. The fact that those two properties do not fit could be atrributed to the heating of the substrate during the deposition. These results clearly show that the properties of rf sputtered CoCr have to be improved. To complete this first study, some parameters have to be optimized: the optimal CoCr thickness still remains unknown and a bias voltage would improve the properties of the layer.

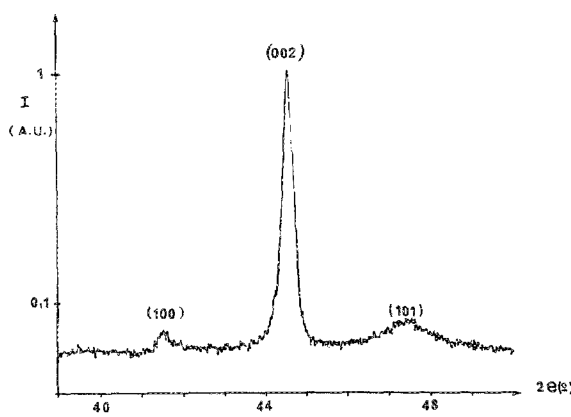

FIG. 9. X-ray diffraction diagram of a CoCr layer deposited in the cylindrical configuration.

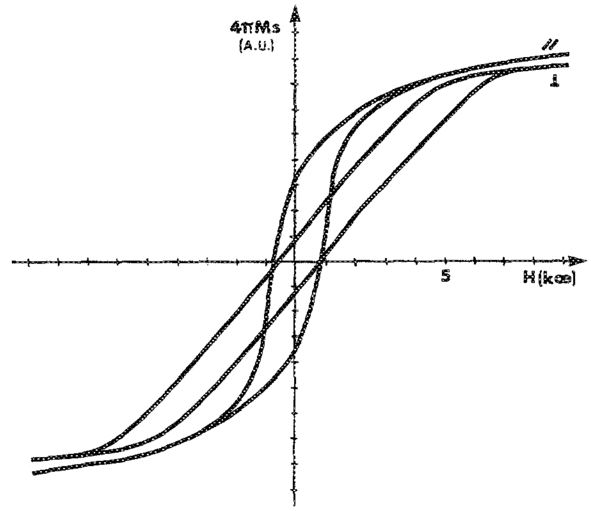

FIG. 10. VSM hysteresis loops of a CoCr layer deposited in the cylindrical configuration.

IV. CONCLUSIONS

Based on planar configuration results, a specially designed rf sputtering group has been built for the deposition of thick CoCr layers ($\simeq 10\ \mu$m) on full-size drums for a magnetographic printer. In spite of such large thicknesses, the vertical magnetic anisotropy still exists in the plane films. The crucial point of the deposition process was the pre-etching of the substrate. Then, the incident power was optimized for the deposition of CoCr. The deposited layers are structurally well oriented, but the heating of the substrate during the deposition is thought to be responsible for their weak vertical magnetic anisotropy. The temperature of the drum, bias voltage and thickness of the layer must be optimized for magnetography. This study has shown, for the first time, that a magnetographic drum can be obtained by a dry deposition process.

ACKNOWLEDGMENT

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[1]Jones, Mechanics Magazine, 385 (1839).
[2]J. J. Eltgen and J. Magnenet, IEEE Trans. Magn. **MAG-16**, 961 (1980).
[3]S. Iwasaki and Y. Nakumura, IEEE Trans. Magn. **MAG-13**, 1272 (1977).
[4]J. J. Eltgen, J. Am. Chem. Soc., Product R and D, **24**, 196 (1985).
[5]D. Jeanniot and J. Desserre, J. Phys. (Paris) **C6-105**, 446 (1985).