TEMPERATURE DEPENDENCE OF THE COERCIVITY OF ACICULAR γ-Fe_2O_3 SURFACE MODIFIED WITH COBALT[1])

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Cobalt-modified γ-Fe_2O_3 with acicular particles is used for high density magnetic recording. This paper reports the temperature dependence of Co-modified γ-Fe_2O_3 coercivity with regard to the method of forming a Co compound layer on oxide particles. The results show the advantage of the method by which a defined Co containing layer without cobalt penetration into the oxide core on the surface of oxide particles arises.

ТЕМПЕРАТУРНАЯ ЗАВИСИМОСТЬ КОЭРЦИТИВНОЙ СИЛЫ ИГОЛЬЧАТОЙ γ-Fe_2O_3, ПОВЕРХНОСТНО МОДИФИЦИРОВАННОЙ КОБАЛЬТОМ

Для магнитной записи сигнала с высокой разрешающей способностью была использована модифицированная кобальтом гамма-окись железа с частицами игольчатой формы. Изучалась температурная зависимость коэрцитивной силы этого окисла с учетом способа образования модифицирующего слоя соединения кобальта. Полученные результаты показывают преимущество примененного метода, при котором на поверхности частицы образуется слой, содержащий кобальт, без проникновения ионов кобальта в само ядро частицы.

I. INTRODUCTION

Gamma-ferric oxide with acicular particles is the most used magnetic material in the production of magnetic recording media. Its coercivity (max. 300 A cm^{-1}) is but insufficient for contemporary demands on the recorded signal density. Hence, for example, to videorecording acicular γ-Fe_2O_3 modified with small quantities of cobalt (usually 2—5 %) is applied, its H_c being in the range of 400—700 A cm^{-1}.

Nevertheless, the cobalt modification may bring with it some disadvantageous properties. Whilst the coercivity of acicular pure γ-Fe_2O_3 particles is essentially determined by their shape anisotropy and varies with increasing temperature only very little, the modification with cobalt added to the whole volume of γ-Fe_2O_3 particles brings not only an increase of H_c but also its conditioning of the magnetic crystal anisotropy with its constant K_1 expressively temperature dependent [1]. Consequently, also H_c of the modified oxide varies with temperature in a considerable measure. In practice, it means the deterioration of carrier recording properties (increased print-through, loss of signal level).

These disadvantages can be suppressed to a considerable extent — with H_c kept sufficiently high — if cobalt is concentrated only in the surface layer of the γ-Fe_2O_3 particles [2, 3]. For the purpose of forming this layer, several procedures can be employed. The paper presents a study of the connection between the way of Co application on the surface of the γ-Fe_2O_3 particles and the growing influence of magnetic crystal anisotropy manifested in the temperature dependence of H_c.

[1]) Contribution presented at the 7th Conference on Magnetism, KOŠICE, June 5—8, 1984.

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II. EXPERIMENTAL PART

Basic γ-Fe_2O_3 used had acicular particles of 0.34 μm length with a ratio $l/d = 6$. Individual samples were surface modified with cobalt in the following way:

Sample 1A — initial γ-Fe_2O_3 was dispersed in a water solution of a Co^{2+} compound, the suspension was alkalized and treated for 4 hours at 368 K.

Sample 1B — the same procedure as with 1A but after separation the product was calcinated for 1 hour at 573 K.

Sample 2A — γ-Fe_2O_3 particles surface was spotted with $Co(CH_3COO)_2$ and the oxide was calcinated in an inert athosphere for 1 hour at 573 K.

Sample 2B — the same procedure as with 2A but calcination at 623 K.

Sample 3A — oxide dispersed in a solution of Co^{2+} and Fe^{2+} compounds, the suspension was alkalized and warmed up for 2 hours at 358 K.

Sample 3B — obtained from calcination of sample 3A in an inert atmosphere at 573 K.

Sample 3C — obtained from calcination of sample 3A in the air at 473 K.

Sample 4 — the oxide was dispersed in a solution of the Co^{2+} compound, the suspension was alkalized and treated in an autoclave for 4 hours at 533 K.

The coercivity of each sample was measured by means of the temperature vibration magnetometer TVM-1 in a magnetic field of the intensity 6000 A cm^{-1} at temperatures 93 and 293 K. The temperature dependence of coercivity is expressed by the coefficient $K_H = H_c$ (93 K)/H_c (293 K).

III. RESULTS

The properties of the prepared γ-Fe_2O_3 samples with their surfaces modified with cobalt are given in Table 1 together with the properties of basic pure γ-Fe_2O_3.

Table 1

Magnetic properties and composition of Co-surface modified γ-Fe_2O_3 samples

Sample	Co^{2+} [%]	Fe^{2+} [%]	H_c (293 K) [A cm^{-1}]	K_H
pure γ-Fe_2O_3	—	—	239	1.29
1A	2.82	—	262	1.28
1B	2.82	—	301	2.69
2A	2.90	2.44	515	4.00[a]
2B	2.90	4.88	569	4.20[a]
3A	2.65	6.48	482	1.80
3B	2.65	6.57	532	3.85
3C	2.65	2.02	352	2.30
4	3.77	—	475	1.67

a) The intensity of the magnetic field of the magnetometer was not sufficient enough to saturate the sample at the temperature 93 K.

IV. DISCUSSION

All the investigated procedures of the surface modification led to a coercivity increase of the basic sample of γ-Fe_2O_3. The effect of procedures herein described is different and indicates that the increase of H_c was achieved by a different mechanism. This is significantly manifested in the temperature stability of H_c of each of the samples and hence, in their utilization ability for magnetic recording. In all cases, the surface coating containing Co was being formed on γ-Fe_2O_3 particles, yet with samples 1B, 2A, 2B, 3B and partly also 3C the growth of H_c was conditioned by Co diffusion from the originally spotted layer into the interior particles volume. This is proved by a marked growth of magnetic crystal anisotropy influence on coercivity appearing as its temperature instability. The presence of ions Fe^{2+} makes the Co diffusion to the oxide core easier, as it becomes evident from the properties of samples 1B and 2A calcinated at the same temperature. The most advantageous are the procedures applied to samples 3A and 4 since at a sufficient increase of coercivity its temperature dependence gets very near to the H_c temperature dependence of pure γ-Fe_2O_3.

V. CONCLUSIONS

Using a suitable procedure it is possible to prepare cobalt surface modified γ-Fe_2O_3, the coercivity of which corresponds to the requirements of high density magnetic recording. The ways of modification requiring for the treatment of γ-Fe_2O_3 temperatures above 473—523 K are unsuitable as they are acompanied by Co diffusion into the core of γ-Fe_2O_3 particles connected with the increasing influence of magnetic crystal anisotropy on oxide coercivity, deteriorating the H_c temperature stability. Successful are those procedures which increase the H_c by forming a defined surface layer (containing $CoFe_2O_4$, event $Co_xFe_{1-x}Fe_2O_4$) without a greater penetration of cobalt ions to the core of the oxide particles. The coercivity of oxide modified in this way is temperature dependent only to a measure profitable for the properties of the resulting recording carrier.

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Received January 4th, 1985