MAGNETIC ALUMITE DISC FOR PERPENDICULAR RECORDING

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ABSTRACT

Details of making are given of perpendicular magnetic alumite discs obtained by an aid of anodization with the additional new process named "pore widening" which was effective to control the coercive force. The electro-deposited fine iron needles were in single crystalline state. The perpendicular orientation of magnetization was confirmed. The magnetic recording characteristics of rigid discs indicated a hilgh potential for use as a perpendicular recording medium.

INTRODUCTION

Much effort has been devoted to developing the perpendicular recording techniques proposed by Iwasaki [1], while the investigation of perpendicular recording media has centered on sputtered Co-Cr films [2]. A number of other films such as sputtered Co-Cr-Rh [3], evaporated Co-Cr [4] and electroless-deposited Co-Ni-Mn-Re-P [5] have also been reported as possible candidates for perpendicular recording media. Ba-ferrite films have been investigated, using both coating [6] and sputtering [7] techniques. Recently, in alumite films containing electro-deposited ferromagnetic metals and alloys, we found a new way of increasing the diameter of the pores and lowering the coercive force to a value suitable [8] [9] for perpendicular recording while previous alumite films exhibited too high coercive force [10] . This paper describes the details of the preparation and the magnetic properties of magnetic alumite film,mostly hard discs, made by this new anodic oxidation method, from the view point of its use as a perpendicular recording medium.

INITIAL SUBSTRATE MATERIAL

As the substrate material of the alumite hard disc, 4-weight % Mg-Al alloy was used to ensure sufficient hardness for the surface finishing.Special attention was given to seeing that the aluminium starting material was at least 99.99% pure in order to form an anodic oxidized layer with regularly developed hexagonal cells.Each cell was accompanied by ultra-fine micropores.1.9mm thick circular plates were prepared. The surface of these substrates was finished by diamond turning, and mirror-face with a surface roughness of far less than 0.01 μm was obtained. To obtain an extremely homogeneous oxide layer, which could only be formed on the contamination-free surface of the substrates without a naturally oxidized top layer, the substrates were subjected to an alkali etching. This processs was typically performed for 20 second in an aquatic solution containing 5 % NaOH at 20 - 70 ℃. Substrates thus obtained were neutralized in 6% HNO_3 for one minute and soaked.

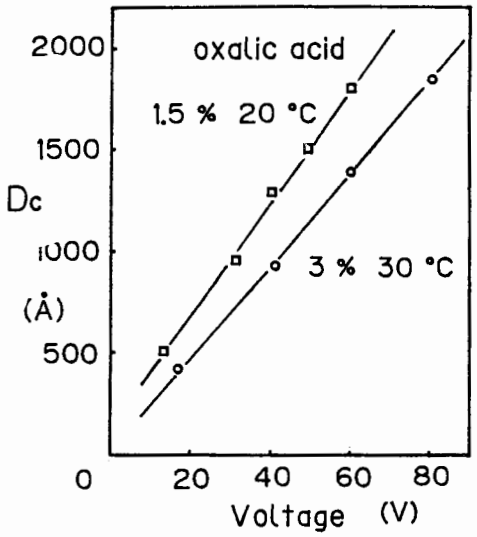

Fig.1. Cell diameter Dc against electrolytic voltage V

ANODIC OXIDATION

The alumite films with cells accompanying ultra fine pores into which iron was electro-deposited were obtained by an anodic oxidation process. This oxidation was performed in 3-weight % oxalic acid or a sulfulic acid N_2 bubbled bath at between 20 to 30℃. By this this process regulary developed hexagonal close-packed uniform thick columnar Al_2O_3 cell structure was produced as a top layer of the aluminium anode. In each cell a pore with a diameter Dp of a few hundred angstroms was formed along the central axis of the cell. As shown in Fig 1 the cell diameter Dc is proportional to the electrolytic voltage V. Acording to this rule, keeping the electrolytic voltage V to a certain constant value between 15-65 volts, the anodization was performed and results in an oxide layer with a certain cell diameter Dc. This size was determined by Scanning Electron Microscope SEM as described later. The amount of charge

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was monitored and the electrolysis was completed after satisfaction of a sheduled charge amount which was proportional to the thickness of the oxide layer.

PORE WIDENING

When alumite substrate was subjected to electro-deposition without any special treatment for pore size, the coercive force of the magnetic films formed by the deposition showed value too high compared with the head-field. We succeeded in reducing the coercive force to less than around one thousand oersteds by introducing a new process called pore widening, in which the anodized substrate was treated in a 1-% phosphoric-acid at 20-40 ℃ to dissolve the inner wall of each cell from the pore side. A special temperature control was employed because the pore size Dp was sensitive to the temperature of the sol4ution. Dp could be enlarged from its initial size, which is about Dc/3, up to the cell size Dc as shown in Fig.2. Coercive force , shown in Table Ⅰ,

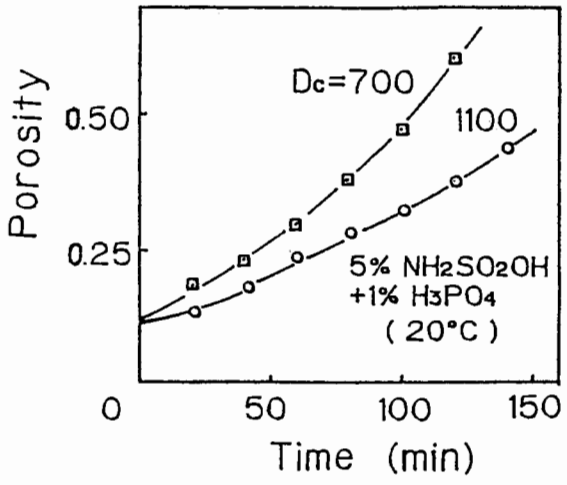

Fig.2. Porosity $(Dp/Dc)^2$ vs. pore widening time

of the magnetic alumite film formed after electro-deposition depends only upon Dp and not Dc as reported [10]. The remarkable effect of the pore widening process is not only control of the coercive force, but also the increase of porosity, which is really proportional to the magnetic flux density of the films as shown in Fig.3. The widened pore diameters produced in the oxidized Al plates were determined by the pore filling method of Nagayama[12]. In this method, the oxide layer was again anodized in an unsoluble neutral solution, 0.5 M H_3BO_3-0.05 M Na_2B_2 at 20℃.

Table Ⅰ, Coercive force Hc vs. pore diameter Dp

Pore diameter Dp(A)	180	250	400	600	920
Hc(Oe)⊥	2100	1780	1000	480	250
Hc(Oe)//	500	520	320	200	200

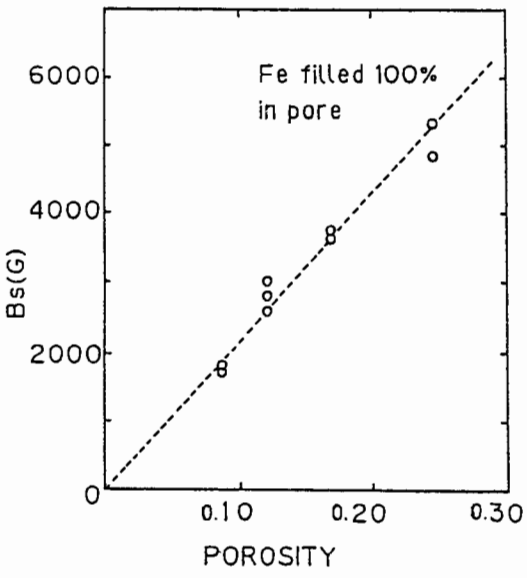

Fig.3. Porosity dependence of saturation flux density Bs

ELECTRO-DEPOSITION

The bottom of the pore mentioned above and the Al base were separated by a dense layer called a barrier layer which was electronically conductive. To realize a uniform deposition rate among pores, the thickness of the barrier layer at the base of each pore should be homogenized. For this purpose the same 1 % phospholic-acid solution as for the pore widening was used. Typically, the current density of 30mA/dm² from the Al side was first flowed for several minutes , then the voltage was raised to 10-20 volts for a few minutes, and the thickness of the barrier layer became uniform.

Electro-deposition was carried out in an iron sulphate bath at 20-60℃ with the aid of a special current consisting of a direct current with a suitable super imposed alternating current. Typically, the peak current densities were 1.6 Amp/dm² and -0.4 Amp/dm². Effectively 0.9 Amp/dm² was the avarage current. It should be noted that observations were made of the voltage-current Lissajous figure to monitor a reasonably proper deposition process. Typically the deposition was performed in 0.1-1mol/l solution of a pH 4-5 iron sulfate bath added

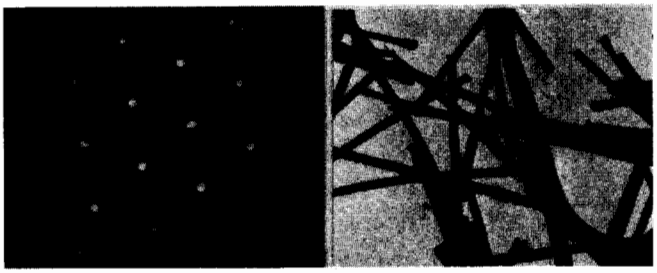

Fig.4. Single crystal iron needles

with 30 gr/l H_3BO_3 at 20-60℃. When stability was requested, a small amount of stabilizing agent, such as $MgSO_4$, glycerin or others was introduced. An overdeposition was easily detected the lightening of the surface' color. It is noted that the electro-deposited needels are pure electrolytic iron as shown in Fig.4.

POLISHING AND OVER-CORTING

After electro-deposition, the magnetic film was subjected to special buff polishing using silica-sol for few minuites. The total indicated run-out of the discs was less than 10μm. Surface roughness of far less than 0.01μm was attained. The Newtonian ring inspection was sometimes convenient for the quick testing of the surface status. A differential-interferrometric microscope was used for observation of the local surface roughness of the discs.The film thickness under test was prepared from 1.5 μm to 5μm.

Coating of the surface polished discs by sputtered SiO_2 for 0.02μm was effective not only for surface protection against erroneous touching but also for corrosion against long term working environmental atmosphere. The small amount of lubricant, appropriate for the present pore structure, typically fluorocarbon, was applied to the surface of the discs for testing.

RECORDING CHARACTERISTICS

The rigid alumite discs were measured by a Mn-Zn ring head with 0.5 μm gap,20μm track width driven at 10m/s. High recording density D_{50} with high output as well as its emvelope were satisfactorily detected. Concerning the recording properties with their dependability are shown in Table II

Table II. Recording characteristics

Output voltage(at 20 kBPI)	1.2Vpp/m T
Recording density	50 kBPI
Signal to noise ratio	29.2 db
Overwrite moduration	less than -30 db
Life test	40℃ 90% RH,1000 hr pass OK
(Over coated by SiO_2 200A)	3ppm H_2S, 10ppm SO_2. 40℃ 75% RH,72 hr OK
	contact start stop 30000 OK
Missing	(55 % threshold) 5/surface unchanged

SUMMARY

The details of the fabrication of alumite rigid discs by introduceing the pore widening method were given. Satisfactory recording characteristics with dependability in life tests were confirmed.

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