

DESCRIPTION

MAGNETIC DISK SUBSTRATE AND MAGNETIC RECORDING MEDIUM
THEREOF

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TECHNICAL FIELD

The present invention relates to a magnetic disk substrate, and a magnetic recording medium using the same. More specifically, the present invention relates to a magnetic disk substrate which can achieve a magnetic recording medium which enables reading and writing that is compatible with high recording density.

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This application claims the priority benefit of Japanese Patent Application No. 2005-361719, filed December 15, 2005, and the priority benefit of U.S. Provisional Application No. 60/752,394, filed on December 22, 2005, the contents of which are incorporated herein by reference.

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BACKGROUND ART

In recent years, much higher recording density is expected in magnetic disks. In order to meet this requirement, extensive studies have been made on the surface topography of the substrate used in magnetic disks. For example, patent document 1 proposes a condition in which the amplitude of the surface waviness of a wave-length from 0.3 mm to 3.0 mm is made 50 nm or less, and the surface roughness is modified to $R_a = 2$ nm to 7 nm, and $R_{max} = 10$ nm to 60 nm. Also, patent document 2, for example, proposes a magnetic disk in which the microwaviness of the surface has a cycle of 0.1 mm to 5 mm, and amplitude of 0.1 nm to 1 nm.

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However, in the arts described in patent documents 1 and 2, there are instances

where the magnetic head collides with the irregularities on the surface of the substrate when the magnetic head moves thereover, and these could not sufficiently comply with the above-mentioned requirement of high recording density.

Furthermore, patent document 3 describes a glass substrate in which, letting the height of the waviness, which generates on the surface of the substrate, measured by using an interferometer for versatile disks at a measuring wave-length (λ) of 0.4 mm to 5.0 mm be W_a (nm), and letting the height of the microwaviness, which generates on the waviness, measured by using a microscopy for three-dimensional surface-structural analysis at a measuring wave-length (λ) of 0.2 mm to 1.4 mm be NR_a (nm), W_a is 0.8 or less, and the ratio of NR_a to W_a (NR_a/W_a) is 1/1.5 or less if W_a is 0.4 or less; 1/2 or less if W_a is greater than 0.4 to 0.5; and 1/3 or less if W_a is greater than 0.5 to 0.8.

Patent Document 1: Japanese Unexamined Patent Application, Publication No. H6-96436

Patent Document 2: Japanese Unexamined Patent Application, Publication No. 2000-207733

Patent Document 3: Japanese Unexamined Patent Application, Publication No. 2003-223711

DISCLOSURE OF INVENTION

However, the glass substrate described in patent document 3 was of no practical use because it was difficult to mass-produce. Specifically, the value of W_a in substrates currently mass-produced is about 0.3 nm, but suppose that the value of W_a is 0.3 nm in the art of patent document 3, the ratio of NR_a to W_a (NR_a/W_a) would have to be 0.6 or less, and this would require a lot of time and effort for production, worsen the yield, and consequently, it would be difficult to mass-produce.

The present invention results from studies on above-described circumstances, and the object of the present invention is to provide a magnetic disk substrate which can achieve a magnetic recording medium which enables reading and writing that is compatible with high recording density, can be mass-produced, and has excellent
5 electromagnetic conversion characteristics, and to provide a magnetic recording medium using the same.

In order to solve the above-described problems, the inventors discovered that a magnetic disk substrate which can be mass-produced and has excellent electromagnetic conversion characteristics can be obtained by manufacturing the substrate such that the
10 amplitude W_a of the waviness on the surface measured by using an interferometer for versatile disks at a measuring wave-length of 5.0 mm (hereinafter, abbreviated as “the amplitude of the waviness”) is within the range of 0.1 nm to 0.5 nm; the average amplitude W_b of the microwaviness generated on the above-mentioned waviness measured by using a microscopy for three-dimensional surface-structural analysis at
15 measuring wave-length of 30 μm to 200 μm (hereinafter, abbreviated as “the average amplitude of the microwaviness”) is 0.3 nm or less; and the value calculated by dividing the average amplitude W_b of the microwaviness by the amplitude W_a of the waviness, namely W_b/W_a , is 0.6 or more.

In addition, in the present invention “the amplitude W_a of the waviness” refers
20 to the amplitude represented by the waviness curve of the reference wave-length of 5.0 mm, as shown in FIG. 1A. Also, as shown in FIG. 1B, “the average amplitude W_b of the microwaviness” refers to the amplitude of the microwaviness generated on the waviness, namely the amplitude of the microwaviness represented if the waviness curve were linear (arithmetic average roughness R_a).

25 In detail, as the amplitude W_a of the waviness of the substrate becomes large,

the magnetic head cannot track the waviness of the substrate in the magnetic recording medium thereof, and there is concern that the output waveform of the electromagnetic conversion is disrupted because of this. If the amplitude W_a of the waviness of the substrate is quite large, then, the magnetic head crashes into the magnetic recording
5 medium. To the contrary, the inventors discovered that a magnetic recording medium with excellent electromagnetic conversion characteristics can be achieved by making the amplitude W_a of the waviness of the substrate less than 0.5 nm.

Also, the inventors confirmed that the output waveform of the electromagnetic conversion of the magnetic recording medium was disrupted irrespective of the
10 amplitude W_a of the waviness of the substrate even if the amplitude W_a of the waviness of the substrate was adjusted to less than 0.5 nm when the flying height of the magnetic head was lowered. Moreover, the inventors found that the disruption of the output waveform got worse as the average amplitude W_b of the microwaviness became large when the amplitude W_a of the waviness of the substrate was made less than 0.5 nm.
15 Then, the inventors discovered that a magnetic recording medium with excellent electromagnetic conversion characteristics can be achieved by making the average amplitude W_b of the microwaviness 0.3 nm or less as well as by making the amplitude W_a of the waviness of the substrate less than 0.5 nm, and further by adjusting the value W_b/W_a to 0.6 or more, which is calculated by dividing the average amplitude W_b of the
20 microwaviness by the amplitude W_a of the waviness.

Also, in terms of electromagnetic conversion characteristics, it is preferable that the amplitude W_a of the waviness of the substrate, and the average amplitude W_b of the microwaviness be much smaller, but it gets difficult to mass-produce as it gets smaller and smaller. For example, in order to make W_b small, it is effective to make the particle
25 size of the abrasive used in the process of polishing the substrate much smaller.

However, in this case, the speed of polishing the substrate must be slowed, so productivity decreases. Therefore, the inventors studied the above-described problems, and achieved the present invention. That is, the present invention relates to the followings.

5 (1) A magnetic disk substrate in which the amplitude W_a of the waviness on the surface measured by using an interferometer for a versatile disk at a measuring wave-length of 5.0 nm is within the range of 0.1 nm to 0.5 nm, the average amplitude W_b of the microwaviness generated on the above-mentioned waviness measured by using a microscopy for three-dimensional surface-structural analysis at a measuring
10 wave-length of 30 μm to 200 μm is 0.3 nm or less, and the value of W_b/W_a , which is calculated by dividing the average amplitude W_b of the microwaviness by the amplitude W_a of the waviness is 0.6 or more.

(2) The magnetic disk substrate according to (1) which is made from glass.

(3) The magnetic disk substrate according to (1) which is made from silicon.

15 (4) A magnetic recording medium which includes the above-described magnetic disk substrate according to any one of (1) to (3).

According to a magnetic disk substrate of the present invention, in which the amplitude W_a of the waviness is within the range of 0.1 nm to 0.5 nm, the average amplitude W_b of the microwaviness is 0.3 nm or less, and the value calculated by
20 dividing the average amplitude W_b of the microwaviness by the amplitude W_a of the waviness, namely W_b/W_a , is 0.6 or more, a magnetic recording medium which can be mass-produced, has excellent electromagnetic conversion characteristics, and enables reading and writing that is compatible with high recording density can be achieved.

Also, the magnetic recording medium of the present invention enables reading
25 and writing that is compatible with high recording density because it uses the magnetic

disk substrate of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A illustrates the amplitude W_a of the waviness.

5 FIG. 1B illustrates the average amplitude W_b of the microwaviness in the present invention.

FIG. 2 is a diagram showing one example of the magnetic recording medium of the present invention.

10 FIG. 3 is a flow diagram illustrating one example of the process of producing the magnetic disk substrate of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the embodiments of the present invention are described by referring to the figures. However, the present invention is not limited to the embodiments as
15 described below.

FIG. 1A illustrates the amplitude W_a of the waviness. FIG. 1B illustrates the average amplitude W_b of the microwaviness in the present invention. In FIG. 1A, W_a represents the amplitude of the waviness. In FIG. 1B, W_b represents the average amplitude of the microwaviness.

20 FIG. 2 is a diagram showing one example of the magnetic recording medium of the present embodiments.

In FIG. 2, "1" shows a magnetic recording medium. The magnetic recording medium 1 includes a magnetic disk substrate 2; and primary coats 3 of chromium alloy, magnetic layers 4 of cobalt alloy, and carbon layers 5 of diamond-like carbon which are
25 formed in order on both sides of magnetic disk substrate 2.

In the magnetic disk substrate 2 shown in FIG. 2, the amplitude W_a of the waviness is within the range of 0.1 nm to 0.5 nm, the average amplitude W_b of the microwaviness is 0.3 nm or less, and the value calculated by dividing the average amplitude W_b of the microwaviness by the amplitude W_a of the waviness, namely
5 W_b/W_a , is 0.6 or more.

When the amplitude W_a of the waviness of the substrate is over 0.5 nm or when the average amplitude W_b of the microwaviness is over 0.3 nm, the electromagnetic conversion characteristics of the magnetic recording medium 1 become inferior, and therefore, such conditions are not preferable. Also, when the amplitude W_a of the
10 waviness of the substrate is less than 1 nm or when the value calculated by dividing the average amplitude W_b of the microwaviness by the amplitude W_a of the waviness, namely W_b/W_a , is less than 0.6, it is required for the production to take a lot of time and effort, the yield gets worse, and it would be difficult to mass-produce. In particular, the substrate whose amplitude W_a of the waviness is less than 0.1 nm is difficult to produce.

15 Also, the magnetic disk substrate 2 shown in FIG. 2 can be made from glass, but this may be made from silicon.

The substrate 2 for magnetic disks, for example, can be produced by way of the method described below.

Firstly, glass is prepared as a raw material for the magnetic disk substrate 2, this
20 raw material glass is molten, mixed and pressed, and a plate of glass which is disk-shaped is made. Then, the crystal nuclei are formed and the crystals are formed therein by heat-treating the obtained plate of glass, a crystallized glass is formed in which the crystal phases are lithium disilicate and α -quartz, particles of the aggregated α -quartz are dispersed on the glass.

25 Next, as illustrated in FIG. 3, the plate of crystallized glass is perforated with a

cylindrical grinding stone, a central aperture is formed in the central portion of the plate of crystallized glass, and a substrate is prepared (S1). After this, a two-stage lapping process, namely a rough-lapping process (S2) and a fine-lapping process (S3) is conducted on one side of the obtained substrate which becomes a main surface, so that
5 the width and surface-roughness of the substrate are adjusted. Then, the inner and outer circumferential portions of the substrate are chamfered in a chamfering process (S4) in order to form chamfered portions.

After the chamfering process, the inner and outer circumferential portions of the substrate are mirror-finished in a mirror finishing process (S5), and a visual examination
10 is conducted thereon (S6).

In the next polishing process, the two steps of (1) a rough-polishing process (S7) and (2) a fine-polishing process (S8) are conducted.

The rough-polishing process of (1) is conducted by using a device which can polish both sides of a substrate, and an abrasive containing cerium oxide.

15 Furthermore, the main surface of the substrate is mirror-finished by conducting the fine-polishing process (S8).

Also, the fine-polishing process can be carried out by using the device which can polish the both sides of substrate, and an abrasive containing at least one of cerium oxide powder and colloidal silica. It is preferable that the abrasive whose particle size
20 is 0.1 μm to 1 μm be used in the fine-polishing process. If the particle size of the abrasive is over 1 μm , the amplitude W_a of the waviness tends to be large, and therefore, it is not preferable. If the particle size of the abrasive is less than 0.1 μm , its processing rate is lowered, and it is difficult to mass-produce. In addition, when plural abrasives are mixed for use, it may include abrasives which are different in particle size.

25 Also, in the fine-polishing process, a pad made from a urethane or suede can be

used.

Finally, the magnetic disk substrate shown in FIG. 2 can be obtained by washing the substrate (S9).

In order to produce the magnetic recording medium 1 shown in FIG. 2 using the magnetic disk substrate 2 obtained in this way, at first, the magnetic disk substrate 2 is mounted in sputtering equipment, and primary coats 3 made from chromium alloy, and magnetic layers 4 made from cobalt alloy are successively formed on both sides of the magnetic disk substrate 2 by way of sputtering. Then, the carbon layers 5 made from diamond-like carbon are formed on the magnetic layers 4 by way of the CVD method, and the magnetic recording medium 1 shown in FIG. 2 can be obtained. In addition, the carbon layers 5 may be coated with Fonblin Z-Tetraol (produced by Sovay Solexis Inc.) as a lubricant.

Example

Hereinafter, an example is shown in order to demonstrate the beneficial effects of the present invention. However, the present invention is not limited to the embodiments verified below.

(Test Cases 1 to 12)

A raw material glass mainly including 77% of SiO_2 , 11% of Li_2O , 4% of Al_2O_3 , and 3% of MgO was prepared as a material for each magnetic disk substrate. The raw material glass was molten at approximately 1350°C to 1500°C by using a melting device, and this was mixed, pressed and cooled, and a disk-like plate of glass having a diameter of 66 mm, and width of about 1 mm was obtained. Then, the obtained plate of glass was heat-treated at 540°C for about five hours to form crystal nuclei, the crystals were formed at 780°C for two hours, and the crystallized glass was formed in which the crystal

phases were lithium disilicate and α -quartz, and particles of the aggregated α -quartz were dispersed on the glass.

Next, a central aperture was formed in the central portion of the plate of crystallized glass by using a cylindrical grinding stone, and a substrate was prepared.

5 Then, the two-stage lapping process including a rough-lapping process and fine-lapping process was conducted to one side of the obtained substrate which became a main surface by using a polishing device which can polish the both sides of substrate and uses a diamond pellet, and the thickness and surface-roughness of the substrate were adjusted. Then, the inner circumferential portion of the substrate, which fronts on the central
10 aperture, and the outer circumferential portion were chamfered with a grinding stone by using an internal-external processing device, and chamfered portions are formed.

After the chamfering process, the inner and outer circumferential portion was mirror-finished, visual examinations were conducted thereon, and the main surfaces of the substrates were finally mirror-finished by using the polishing device which can polish
15 the both sides of substrate. This polishing process included a rough-polishing step and fine-polishing step. The abrasive containing cerium oxide powder (ceria) ("ROX" produced by Showa Denko K.K.), and colloidal silica ("Compol" produced by Fujimi Incorporated) was used therein. Commercially available urethane or suede pads were used for polishing them. Finally, each magnetic disk substrate corresponding to Test
20 Cases 1 to 12 were obtained, which were different in the amplitudes W_a of the waviness, and the average amplitudes W_b of the microwaviness, but had an identical diameter of 65 mm, and internal diameter of 20 mm.

The abrasives used in the fine-polishing process, and their particle sizes are shown in Table 1.

Table 1

Case #	Wa (nm)	Wb (nm)	Wb/Wa	Abrasive	Particle size of abrasive (μm)	Yield	Evaluation of Yield	Electromagnetic conversion characteristics	Electromagnetic conversion characteristics
1	0.78	0.35	0.45	Ceria	0.8	1.85	Good	0.89	Bad
2	0.75	0.29	0.39	Ceria	0.8	1.62	Good	0.90	Bad
3	0.62	0.19	0.31	Ceria	0.8	1.56	Good	0.92	Bad
4	0.61	0.18	0.30	Ceria	0.8	1.35	Good	0.94	Bad
5	0.42	0.19	0.45	Ceria	0.2	0.85	Bad	1.01	Good
6	0.39	0.21	0.54	Ceria	0.2	0.83	Bad	1.00	Good
7	0.32	0.16	0.50	Ceria	0.2	0.73	Bad	1.02	Good
8	0.30	0.22	0.73	Ceria/Colloidal silica	0.45 / 0.08	1.00	Good	1.00	Good
9	0.21	0.23	1.10	Ceria/Colloidal silica	0.45 / 0.08	0.97	Good	1.00	Good
10	0.2	0.32	1.60	Ceria	0.45	0.12	Good	0.95	Bad
11	0.25	0.14	0.56	Colloidal silica	0.08	0.27	Bad	1.04	Good
12	0.2	0.09	0.45	Colloidal silica	0.06	0.08	Bad	1.07	Good

The above-obtained substrates of Test Cases 1 to 12 were scrub-brush washed, further ultrasonically cleaned in an oxalic acid solution, and extraneous matters attached on the surfaces were removed. Then, the amplitudes W_a of the waviness, and the average amplitudes W_b of the microwaviness of the substrates were measured. The results are shown in Table 1.

The amplitudes W_a were obtained by using an interferometer "OptiFlat" produced by ADE Phase Shift, Inc. with a high-pass filter of 5 mm. Also, the average amplitudes W_b of the microwaviness were measured at a measuring wave-length of 30 μm to 200 μm by using MicroXam with a band-pass filter.

With regard to the substrates of Test Cases 1 to 12, their yields were evaluated. The results are shown in Table 1.

The results of the processing rates measured in the fine polishing processes are evaluated as the followings:

Good: the relative value of the processing rate was 1 or more when the processing rate of Test Case 8 was regarded as 1; or

Bad: the relative value of the processing rate was less than 1 when the processing rate of Test Case 8 was regarded as 1.

Each of the substrates of Test Cases 1 to 12 was texture-treated by using a non-woven fabric and a diamond slurry, then loaded into sputtering equipment, and primary coats of chromium alloy and magnetic layers of cobalt alloy were formed on both sides of the substrate by way of sputtering. Then, diamond-like carbon layers were formed thereon by way of the CVD method, a lubricant "Fonblin Z-Tetraol" (produced by Solvay Solexis, Inc.) was coated thereon, and a magnetic recording medium was produced.

In addition, the sum of the thicknesses of the primary coat and the magnetic

layer was 90 nm, and the thickness of the diamond-like carbon layer was 10 nm.

Next, with regard to the above-obtained magnetic recording media of Test Cases 1 to 12, their electromagnetic conversion characteristics were measured by using an electromagnetic conversion characteristics analyzer produced by Guzik Technical Enterprises. The results are shown in Table 1.

In addition, the results of the electromagnetic conversion characteristics were evaluated as the following:

Good: the relative value of the electromagnetic conversion characteristics was 1 or more when the electromagnetic conversion characteristics of the Test Case 8 were regarded as 1; or

Bad: the relative value of the electromagnetic conversion characteristics was less than 1 when the electromagnetic conversion characteristics of the Test Case 8 were regarded as 1.

The results shown in Table 1 revealed that the substrates of Test Cases 1 to 4, whose amplitudes W_a of the waviness of the substrate were over 0.5 nm, had inferior electromagnetic conversion characteristics. Also, it was revealed that those of Test Cases 1 and 10, whose average amplitudes W_b of the microwaviness were over 0.3 nm, had inferior electromagnetic conversion characteristics.

Furthermore, it was confirmed that those of Test Cases 5 to 7, 11, and 12, whose values calculated by dividing the average amplitudes W_b of the microwaviness by the amplitudes W_a of the waviness, namely W_b/W_a were less than 0.6, had inferior yield even though they had superior electromagnetic conversion characteristics.

INDUSTRIAL APPLICABILITY

According to the present invention, a magnetic disk substrate which can achieve

a magnetic recording medium compatible with high recording density, and has excellent electromagnetic conversion characteristics can be mass-produced. Therefore, the present invention is highly applicable to the field of information technology or the like.

CLAIMS

1. A magnetic disk substrate, wherein

an amplitude W_a of a waviness on a surface measured by using an
5 interferometer for a versatile disk at a measuring wave-length of 5.0 mm is within the
range of 0.1 nm to 0.5 nm;

an average amplitude W_b of a microwaviness generated on the waviness
measured by using a microscopy for three-dimensional surface-structural analysis at a
measuring wave-length of 30 μm to 200 μm is 0.3 nm or less; and

10 a value of W_b/W_a , which is calculated by dividing the average amplitude W_b of
the microwaviness by the amplitude W_a of the waviness is 0.6 or more.

2. The magnetic disk substrate according to claim 1 which is made from glass.

15 3. The magnetic disk substrate according to claim 1 which is made from silicon.

4. A magnetic recording medium which comprises the magnetic disk substrate
according to any one of claims 1 to 3.