DESCRIPTION

MAGNETIC RECORDING AND REPRODUCING DEVICE

Cross Reference to Related Applications:

This application is an application filed under 35 U.S.C. § 111(a) claiming the benefit pursuant to 35 U.S.C. § 119(e)(1) of the filing dates of Provisional Application No. 60/580,907 filed June 21, 2004 and Japanese Patent Application No. 2004-168266 filed June 7, 2004 pursuant to 35 U.S.C. § 111(b).

Technical Field:

This invention relates to a magnetic recording and reproducing device for recording and reproducing a magnetic signal.

Background Art:

The hard disk drive (HDD) which is one kind of the magnetic recording and reproducing device has been conspicuously exalting the recording density in recent years. To date, even in the mass-produced version of this device, the recording density has reached 80 Gbpsi (giga bits/square inch). As a result, even in the HDD of the small size, the exaltation of capacity has become feasible. At the recording density of 80 Gbpsi, for example, the 1-inch HDD is capable of realizing the capacity of 6 GB.

When the HDD of such a small size as about 1 inch in diameter is so improved as to realize a great exaltation of recording capacity, it can be expected to find extensive utility in portable applications, such as portable telephones, portable music players and the PDA as well. The portable music players have already come to include commodities having a 1-inch HDD mounted therein. These commodities have been developing an appreciable market.

As the magnetic recording medium to be used in the hard disk drive, the configuration which results from stacking a metal film by the sputtering technique on the substrate for a magnetic recording medium has been prevailing. As the substrate to be used in the magnetic recording medium, the aluminum substrate and the glass substrate are widely adopted. The aluminum substrate is produced by forming an Ni-P

alloy film in a thickness of about 10 μm by the electroless plating technique on a specularly polished substrate of an Al-Mg-based alloy and further polishing the surface of this film to a specular finish. The glass substrate is known in two kinds, i.e. an amorphous glass and a crystallized glass, which are both produced in a specular finish.

In the magnetic recording medium which is at present generally used for the hard disk drive, a non-magnetic under layer (Ni-Al-based alloy, Cr or Cr-based alloy, for example), a non-magnetic intermediate layer (Co-Cr-, Co-Cr-Ta-based alloy, for example), a magnetic layer (Co-Cr-Pt-Ta-, Co-Cr-Pt-B-based alloy, for example), and a protecting layer (carbon, for example) are sequentially stacked in the order mentioned on a glass substrate or an aluminum substrate. A lubricating film is further formed thereon with a liquid lubricating agent.

Incidentally, the HDD of the small size has the possibility of being applied to numerous portable electronic devices and mobile communication devices as described above. For the HDD to be used as built in such devices, it is required to afford impact resistance and resistance to the environment more than ever. The HDD which is widely used at present, however, does not deserve to be rated as possessing fully satisfactory resistance to impact or to environment and has failed to acquire properties stable enough to find extensive adoption for such devices as mentioned above.

This invention has been initiated in the light of the state of affairs mentioned above and is aimed at providing a magnetic recording and reproducing device which is capable of being extensively applied to portable electronic devices and mobile communication devices and is excellent in resistance to impact and to environment.

Disclosure of the Invention:

With a view to accomplishing the above object, a first aspect of this invention is directed toward a magnetic recording and reproducing device comprising a rectangular box housing having an upper opening and storing therein a magnetic recording medium that has a substrate of silicon and measures 50 mm or less in diameter, a spindle motor that serves as drive means for supporting and rotating the magnetic recording medium, a head suspension assembly that includes a magnetic head adapted to record and reproduce a magnetic signal in the magnetic recording medium and supports the magnetic head movably relative to the magnetic recording medium, a voice coil motor

that rotates and positions the head suspension assembly and a printed circuit substrate that controls motion of the spindle motor and voice coil motor; and a top cover for blocking the upper opening of the housing.

A second aspect of this invention is directed to the magnetic recording and reproducing device according to the first aspect of the invention, wherein the substrate of the magnetic recording medium has a thickness in a range of 0.6 mm to 0.25 mm.

A third aspect of this invention is directed to the magnetic recording and reproducing device according to the first or second aspect of the invention, wherein the magnetic recording medium has impact resistance of 2000 G or more while no magnetic signal is being recorded or reproduced in the magnetic recording medium.

A fourth aspect of this invention is directed to the magnetic recording and reproducing device according to any one of the first to third aspects of the invention, wherein the magnetic recording medium has impact resistance of 300 G or more while the magnetic signal is being recorded or reproduced in the magnetic recording medium.

A fifth aspect of this invention is directed to the magnetic recording and reproducing device according to any one of the first to fourth aspects of the invention, wherein the magnetic recording medium has rotational frequency of 3600 rpm or more.

A sixth aspect of this invention is directed to the magnetic recording and reproducing device according to any one of the first to fifth aspects of the invention, wherein the magnetic recording medium has surface roughness (Ra) in a range of 1.5 Å to 8 Å.

Since the magnetic recording and reproducing device of this invention uses a substrate of silicon for the magnetic recording medium thereof, the magnetic recording medium acquired by the device enjoys scarcity of surface flaw and abundance of resistance to impact and resistance to environment and allows the magnetic recording and reproducing device to be so miniaturized as to fit portable electronic devices and mobile communication devices.

Specifically, owing to the use of silicon abounding in stiffness for the substrate, the magnetic recording medium is allowed to have a diameter of 50 mm or less. This decrease of the diameter allows the device to be miniaturized. Thus, the magnetic recording and reproducing device consequently obtained is suitable for portable electronic devices and mobile communication devices.

Further, owing to the use of silicon abounding in stiffness for the substrate, it is made possible to decrease the thickness of the substrate and miniaturize the device to a further extent.

The device acquires such properties as to exhibit impact resistance of 2000 G or more during the absence of writing or reading (the absence of recording and reproducing) and impact resistance of 300 G or more during the presence of writing and reading (the presence of recording and reproducing). As a result, the device is rendered applicable to portable electronic devices and mobile communication devices.

Owing to the use of silicon abounding in stiffness for the subgstrate, the magnetic recording medium is enabled to withstand rotational frequency of 3600 rpm or more and the magnetic recording and reproducing device is enabled to operate at a higher speed.

Further, since the magnetic recording medium is given surface roughness (Ra) in the range of 1.5 Å to 8 Å and preferably in the range of 2 Å to 6 Å, the flying-height budget of a head medium can be improved and the margin for designing a drive can be enlarged.

The above and other objects, characteristic features and advantages of the present invention will become apparent to those skilled in the art from the description given herein below with reference to the accompanying drawings.

Brief Description of the Drawings:

Figure 1 is a plan view illustrating the HDD contemplated by this invention.

Figure 2 is a side view illustrating the magnetic head part as magnified.

Best Mode for carrying out the Invention:

This invention contemplates using, in the magnetic recording and reproducing device, a magnetic recording medium using silicon for the substrate thereof and giving to the magnetic recording medium a diameter of 50 mm or less.

As the silicon substrate, while a single crystal substrate of such high purity as is used in a semiconductor wafer can be used, a substrate doped with an impurity and a polycrystal substrate may be used. The silicon substrate is capable of improving the smoothness of surface as compared with the glass substrate or the Al substrate which is

generally used as the substrate for the magnetic recording medium and, therefore, is capable of realizing very fine surface properties which are devoid of surface defects and projections. Further, since the crystal grains of a seed layer, an under layer and a magnetic layer formed on the silicon substrate are epitaxially grown, the quality of each layer is improved and the magnetic properties of the magnetic recording medium are enhanced.

In the case of producing a magnetic recording medium using a silicon substrate, a magnetic film may be formed directly on the silicon substrate to give rise to the magnetic recording medium or a textured anisotropic medium. As concrete examples of the texturing method, a method which directly imparts a mechanical texture to a silicon substrate, a method which forms a metal film such as of NiP by sputtering or plating and thereafter effects the impartation of a mechanical texture, and a method which performs a surface treatment as with an oxide film and thereafter effects the impartation of a mechanical texture may be cited. It is also permissible to impart anisotropy as by the rhombic sputtering technique. By giving the surface a texturing work or an etching treatment, it is made possible to control the surface roughness of the magnetic recording medium or control the flying-height property (HDI) of the head.

This invention contemplates giving the magnetic recording medium a diameter of 50 mm or less and preferably 25 mm or less. By giving the magnetic recording medium such a small diameter as mentioned above, the magnetic recording and reproducing device of this invention is enabled to exalt the properties thereof more conspicuously. To be specific, this magnetic recording medium is enabled to exalt the smoothness of surface and the controllability of surface and acquire easily the properties suitable for the HDD of a small diameter as compared with the conventional magnetic recording medium using a glass substrate or an aluminum substrate. The lower limit of the diameter of the magnetic recording medium is about 10 mm.

This invention contemplates giving the substrate of the magnetic recording medium a thickness preferably in the range of 0.6 mm to 0.25 mm and more preferably in the range of 0.35 mm to 0.25 mm. Since the substrate used for the magnetic recording and reproducing device of this invention abounds in stiffness, the substrate is enabled to decrease the thickness thereof and as a result the magnetic recording and reproducing device is enabled to be further miniaturized.

The magnetic recording and reproducing device of this invention acquires such properties as exhibit impact resistance of 2000 G or more during the absence of writing and reading and impact resistance of 300 G or more during the presence of writing and reading. As a result, the device is rendered applicable to portable electronic devices and mobile communication devices, for example.

The magnetic recording medium to be used in the magnetic recording and reproducing device of this invention withstands rotation frequency of even more than 3600 rpm and, therefore, permits provision of a magnetic recording and reproducing device which is capable of high-speed operation.

The surface roughness (Ra) of the magnetic recording medium to be used in the magnetic recording and reproducing device of this invention falls preferably in the range of 1.5 Å to 8 Å and more preferably in the range of 2 Å to 6 Å. The use of the magnetic recording medium of this surface roughness results in improving the flying-height budget of a head medium and as a result permits the margin for designing a drive to be enlarged.

The characteristic features of the magnetic recording and reproducing device of this invention may be summarized as follows.

(1) Since the silicon substrate has a high Vickers hardness, it is allowed to acquire a margin of about 100 G in the impact property during the absence of operation (the impact property during the absence of writing and reading) over the glass substrate which is generally used as the substrate for a magnetic recording medium of the HDD of a small size.

(2) Since the silicon substrate has a high Vickers hardness, it is allowed to acquire a margin of about 100 G as well in the impact property during the presence of operation (the impact property during the presence of writing and reading) over the glass substrate.

(3) Since the silicon substrate has a high Vickers hardness, it enables the magnetic recording medium to decrease the thickness thereof. When it has the thickness thereof decreased by about 10%, it still acquires the same impact resistance as the glass substrate.

(4) Since the silicon substrate enables the surface smoothness of the magnetic recording medium to be improved as compared with the glass substrate, it is allowed to

exalt the budget for the flying-height of a head medium and consequently enlarge the margin for designing a drive.

(5) Since the silicon substrate enables the surface smoothness of the magnetic recording medium to be improved as compared with the glass substrate, it is allowed to exalt the touchdown property of a head and improve the HDD in the resistance to the environment and particularly in the vacuum property. To be specific, the altitude flyability performance is exalted by about 0.1-atmosphere as compared with the glass substrate.

(6) Since the silicon substrate possesses electrical conductivity, it is enabled to prevent the medium surface from electrification by grounding the HDD and consequently improve the resistance to the environment (ESD property).

(7) Since the substrate acquires an addition to stiffness, the magnetic recording medium is prevented from inducing deformation easily, the terminal part of the magnetic recording medium is prevented from contacting other part, and the contamination of the interior of the HDD is suppressed.

(8) Since the substrate acquires an addition to stiffness, the magnetic recording medium is enabled to cope with high-speed rotation.

Now, the invention will be described in detail below with reference to the drawings.

Figure 1 is a plan view illustrating the HDD contemplated by this invention and Figure 2 is a side view illustrating the magnetic head as magnified.

The HDD, as illustrated in Figure 1, is provided with a rectangular box case 12 having an upper opening and a top cover (not shown) blocking the upper opening of the case screwed to the case with screws.

Inside the case 12, magnetic disks 16 as a magnetic recording medium, a spindle motor 18 as a driving part for supporting and rotating the magnetic disks 16, a plurality of magnetic heads 40 for writing and reading information in the magnetic disks 16, a carriage assembly 22 for supporting the magnetic heads 40 movably relative to the magnetic disks 16, a voice coil motor (hereinafter referred to as "VCM") 24 for rotating and positioning the carriage assembly 22, a ramp load mechanism 25 for retaining the magnetic heads 40 at a position of relief separated from the magnetic disks 16 after the magnetic heads 40 have moved to the outermost periphery of the magnetic disks 16,

and a substrate unit 21 furnished with a read-write amplifier as a circuit for processing recording and reproducing signals are contained.

To the outer face of the bottom wall of the case 12, the spindle motor 18 and a printed circuit substrate (not shown) for controlling the operation of the VCM 24 are screwed through the substrate unit 21.

Each of the magnetic disks 16 is provided on the upper side and the lower side thereof with magnetic recording regions. Two magnetic disks 16 are inserted in the outer peripheries of a hub (not shown) of the spindle motor 18 and, at the same time, fixed and supported on the hub with clamp springs17. As a result, the two magnetic disks 16 are coaxially superposed on each other as opposed across a prescribed gap. By driving the spindle motor 18, the two magnetic disks 16 are enabled to rotate together at a prescribed speed in the direction of the arrow mark B.

The carriage assembly 22 is provided with a bearing part 26 fixed on the bottom wall of the case 12 and a plurality of arms 32 extending from the bearing part. These arms 32 are positioned in parallel with the surfaces of the magnetic disks 16 as regularly spaced adjacently and extend in the same direction from the bearing part 26. The carriage assembly 22 is further provided with elastically deformable slender plate suspensions 38. The suspensions 38 are formed of a leaf spring and have basal terminals thereof fixed by spot welding or adhesion to the leading terminals of the arms 32 and extend from the arms 32. The suspensions 38 may be each formed integrally with the corresponding arms 32. The arms 32 and the suspensions 38 jointly form head suspensions. These head suspensions and the magnetic heads 40 jointly form a head suspension assembly.

Each of the magnetic heads 40, as illustrated in Figure 2, is provided with a slider 42 of a substantially rectangular shape and a recording and reproducing head part 44 formed on the end face of this slider 42 and is fixed to a gimbal spring 41 disposed at the leading terminal part of the suspension 38. On each of the magnetic heads 40, the head load L directed toward the surface of the magnetic disk 16 is exerted by the resilience of the suspension 38. During the course of operation, the amount of flying-height of the magnetic heads 40 from the magnetic disks 16 is set at a magnitude of 10.0 nm or less.

The carriage assembly 22, as illustrated in Figure 1, is provided with a supporting frame 45 extending from the bearing part 26 in the direction opposite to the arm 32. This supporting frame supports a voice coil 47 that forms part of the VCM 24. The supporting frame 45 is formed of synthetic resin integrally on the outer periphery of the voice coil 47 is interposed between a pair of yokes 49 fixed on the case 12. These yokes and a magnet (not shown) fixed on one of the yokes jointly form the VCM 24. Then, by conducting electric power to the voice coil 47, the carriage assembly 22 is rotated around the bearing part 26 and the magnetic heads 40 are moved to and positioned on the required track of the magnetic disk 16.

The ramp load mechanism 25 is disposed on the bottom wall of the case 12 and is provided with ramps 51 disposed outside the magnetic disk 16 and tabs 53 extending from the leading terminal of the individual suspensions 38. While the carriage assembly 22 is in the process of rotating toward the position of relief outside the magnetic disk 16, the tabs 53 are made to engage the ramp surfaces formed on the ramps 51 and then ascend by virtue of the inclinations of the ramp surfaces, with the result that the magnetic heads 40 will be unloaded.

In the embodiment illustrated above, the substrate is furnished at the central part thereof with a hole and is inserted into the spindle motor. It has a small hole formed in the central part thereof and consequently can be fixed directly on the upper surface of the spindle motor by means of a machine screw passed through this small hole. In the case of using a substrate which is devoid of any hole, the decrease of the diameter is advantageous in enabling the recording area to be enlarged, and the exaltation of stiffness as compared with the substrate furnished with a hole is effective in respect of the impact resistance. By joining the entire rear surface of the substrate to the spindle motor, it is made possible to prevent the substrate from being deformed and further exalt the impact resistance.

Example 1:

Magnetic recording media were manufactured by preparing a silicon substrate and a glass substrate, both machined to 21.6 mm in outside diameter, 6 mm in inside diameter, and 0.381 mm in thickness, forming thereon a seed layer, a Cr alloy under layer, a magnetic layer, and further a C protective film by the sputtering technique, and

finally coating the uppermost surface of the resultant stacked body with a lubricating film. The substrates both used entirely the same film forming method and material. In the case of the magnetic recording medium using the silicon substrate, the magnetic property was about 500 [Oe] higher in Hc than the medium using the glass substrate. Incidentally, 1 Oe equals 79 A/m.

When the Cr in the under layer and the Co in the magnetic film were tested for orientation by the X-ray analysis, the silicon substrate was found to exhibit exalted orientation.

When the glide property and the roughness were measured respectively by the glide tester and the AFM, the silicon substrate was found to have the glide height lowered by about 1 nm and the Ra lowered by about 2 Å. With the object of testing the magnetic recording media for the flying-height property, the magnetic recording media were tested for touchdown (TD) property/takeoff (TO) property by the use of a head which was used in an actual driving. In the silicon substrate, the TD property was found to be lower by 1 nm or more and the TO property was found to be inferior by about 2 nm. The inferiority of the TO property may be explained by supposing that the surface was so smooth as to induce adhesion of the head.

Example 2:

Magnetic recording media were manufactured by preparing a substrate having a mechanical texture directly imparted to a silicon substrate and a substrate having a mechanical texture superposed on a NiP plate formed in a thickness of 100 nm on a silicon substrate, both machined to 21.6 mm in outside diameter, 6 mm in inside diameter and 0.381 mm in thickness, forming thereon a seed layer, a Cr alloy under layer, a magnetic layer and further a C protective film by the sputtering technique, and finally coating the uppermost surface of the resultant stacked body with a lubricating film in the same manner as in Example 1. Similarly to the ordinary glass substrate and the Al substrate, the impartation of the texture was confirmed to enable the magnetic film to acquire anisotropy and enjoy exaltation of magnetic property and electric parametric performance. When the magnetic recording media were tested for glide property and roughness, these properties were both found to be high as compared with

the medium devoid of a texture. Thus, the media acquired the same flying-height property as the glass substrate.

Example 3:

The media of Example 1 and Example 2 were each set in an actual drive and tested by 3 burst for error rate. The drive used for the test had a medium on one side and used one head. The head was loaded/unloaded by the ramp loading method. The rotational frequency of the disk was 3600 rpm. The measurement was made at only one point in the periphery. Though the magnitudes of BER increased proportionately to the electric properties of a single sample, the number of defects was smallest in the silicon substrate and largest in the glass substrate.

Example 4:

A magnetic recording medium was manufactured by preparing a silicon substrate chamfer-polished and machined to 21.6 mm in outside diameter, 6 mm in inside diameter and 0.381 mm in thickness and forming stacked layers thereon in the same manner as in Example 1. The magnetic recording media using the substrate which had undergone the chamfer-polishing and a substrate which had not undergone the chamfer-polishing were each set in a drive. The drive was tested for impact test using an impact tester. In the non-active impact test, the media both sustained no fracture in their disks on exposure to an impact of 2000 G. In the active impact test, the media both exhibited impact resistance of 300 G or more and the substrate which had undergone the chamfer-polishing exhibited a result higher by about 50 G.

Industrial Applicability:

Owing to the use of silicon abounding in stiffness for the substrate, the magnetic recording medium is allowed to have a diameter of 50 mm or less. This decrease of the diameter allows the device to be miniaturized. Thus, the magnetic recording and reproducing device consequently obtained is suitable for portable electronic devices and mobile communication devices. Furthermore, it is made possible to decrease the thickness of the subtrate and miniaturize the device to a further extent. The device acquires such properties as to exhibit impact resistance of 2000 G or more during the

absence of recording and reproducing and impact resistance of 300 G or more during the presence of recording and reproducing. As a result, the device is rendered applicable to portable electronic devices and mobile communication devices.

Owing to the use of silicon abounding in stiffness for the substrate, the magnetic recording medium is enabled to withstand rotational frequency of 3600 rpm or more and the magnetic recording and reproducing device is enabled to operate at a higher speed. Furthermore, since the magnetic recording medium is given surface roughness (Ra) in the range of 1.5 Å to 8 Å and preferably in the range of 2 Å to 6 Å, the flying-height budget of a head medium can be improved and the margin for designing a drive can be enlarged.

CLAIMS

1. A magnetic recording and reproducing device comprising:

a rectangular box housing having an upper opening and storing therein

a magnetic recording medium that has a substrate of silicon and measures 50 mm or less in diameter,

a spindle motor that serves as drive means for supporting and rotating the magnetic recording medium,

a head suspension assembly that includes a magnetic head adapted to record and reproduce a magnetic signal in the magnetic recording medium and supports the magnetic head movably relative to the magnetic recording medium,

a voice coil motor that rotates and positions the head suspension assembly and

a printed circuit substrate that controls motion of the spindle motor and voice coil motor; and

a top cover for blocking the upper opening of the housing.

2. A magnetic recording and reproducing device according to claim 1, wherein the substrate of the magnetic recording medium has a thickness in a range of 0.6 mm to 0.25 mm.

3. A magnetic recording and reproducing device according to claim 1 or claim 2, wherein the magnetic recording medium has impact resistance of 2000 G or more while no magnetic signal is being recorded or reproduced in the magnetic recording medium.

4. A magnetic recording and reproducing device according to any one of claims 1 to 3, wherein the magnetic recording medium has impact resistance of 300 G or more while the magnetic signal is being recorded or reproduced in the magnetic recording medium.

5. A magnetic recording and reproducing device according to any one of claims 1 to 4, wherein the magnetic recording medium has rotational frequency of 3600 rpm or more.

6. A magnetic recording and reproducing device according to any one of claims 1 to 5, wherein the magnetic recording medium has surface roughness (Ra) in a range of 1.5 Å to 8 Å.