

A BURNISH HEAD

FIELD

- 5 This invention relates to burnishing of a disc, in particular, to a burnish head for levelling irregularities on a disc surface.

BACKGROUND

- 10 Digital data is commonly stored in hard disc drives in concentric circular tracks on a disc surface. Reading and writing of data are carried out by a read/write head. The read/write head is held close to the disc surface and moved from track to track radially with respect to the disc surface as the disc is spun. The distance separating the read/write head and the disc surface is commonly known as flying height. Currently, to increase recording density of a disc, individual bit sizes have to be
15 decreased. This requires operational flying height to be correspondingly decreased, thereby bringing the head closer to the disc surface. At such close proximity, the disc surface needs to have a certain smoothness to minimize inadvertent contact between the head and any irregularities such as asperities on the disc surface during normal reading/writing operations.
- 20 Burnishing is a process to obtain a certain level of smoothness of the disc surface by reducing irregularities on the disc surface. This is typically carried out by flying a burnish head at a predetermined burnish head flying height over a spinning disc. The burnish head flying height is necessarily lower than the operational flying height of a read/write head, so that, as the disc spins, any asperities on the disc surface extending above the burnish head flying height are mechanically
25 removed by the burnish head. It is essential that the burnish head flying height be well controlled to maintain a proper distance between the burnish head and the disc surface during the burnishing process. This is because the disc surface is coated with a thin media overcoat for protection, which may be destroyed if the burnish head flies too close to the disc surface.
- 30 Burnish heads typically comprise a slider having a plurality of pads and supported by a suspension. These pads are usually made of the same material as the slider, such as $\text{TiC-Al}_2\text{O}_3$, and can range from 0.1 mm to 0.7 mm in size. The plurality of pads are disposed on the surface of the slider that is facing the disc, which can be called the slider air bearing surface. At least one of the plurality of pads comes into contact with the disc for levelling surface irregularities on the disc.

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In the past, burnish heads were manufactured by wheel grinding. This limited the design of the pads to simple geometrical shapes such as diamonds, rectangles and triangles. The most commonly used burnish head used to be one with diamond-shaped pads, having a waffle pattern cut directly into the slider air bearing surface by wheel grinding.

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Today, ion-milling has overtaken wheel grinding as it can produce pads with more complex shapes such as teardrops, ellipses and circles. During ion milling, areas designated to become pads are masked, while unmasked areas are etched away to leave raised pads on the air bearing surface.

10 While pads of such shapes have been reported to reduce disc damage during burnishing, to improve removal of asperities the ability to maintain the burnish head flying height and ensure flying stability to reduce extraneous burnish head movement are desired.

SUMMARY

15 According to one aspect of the present invention, there is provided a burnish head for burnishing a disc. The burnish head comprises a slider having an air bearing surface, a leading edge and a trailing edge. A plurality of pads is disposed on the air bearing surface, with at least one of the plurality of pads having a graduated surface.

20 According to another aspect of the present invention, there is provided an apparatus for levelling surface irregularities on a disc. The apparatus comprises a head assembly supported by a suspension; the suspension being attached to actuator head mounting arms. The apparatus further comprises a burnish head mounted on the head assembly. The burnish head comprises a slider having an air bearing surface, a leading edge and a trailing edge. A plurality of pads is disposed on
25 the air bearing surface, with at least one of the plurality of pads having a graduated surface.

BRIEF DESCRIPTION OF THE DRAWINGS

30 These and other aspects and advantages of the present invention are described with reference to the accompanying drawings, in which:

Figure 1 is a plan view of an air bearing surface of a burnish head in accordance with a preferred embodiment of the present invention;

Figure 2 is a three-dimensional view of the air bearing surface of Figure 1;

35 Figure 3 is a simulated air flow on the air bearing surface of Figure 1;

Figure 4 is a simulated air pressure distribution on the air bearing surface of Figure 2; and Figure 5 is a plan view of an air bearing surface of a burnish head in accordance with a second embodiment of the present invention.

5 DETAILED DESCRIPTION

In accordance with the preferred embodiment of the present invention, Figure 1 shows a slider 12 of a burnish head with an air bearing surface 14 having a leading edge 16 and a trailing edge 18. The slider air bearing surface 14 is 2.0 mm by 1.6 mm in size. A plurality of pads is disposed on the air bearing surface 14 in an array laterally symmetrical about a midline 20 of the slider 12. This midline 20 is parallel to the direction of motion of the burnish head relative to the disc. Each of the plurality of pads is substantially elliptical in shape. A row of three air bearing pads 22 are disposed adjacent the leading edge 16. Three staggered rows 24, 26, 28 of burnish pads 30 are disposed behind the air bearing pads 22. The first row 24 comprises three burnish pads, the second row 26 comprises four burnish pads and the last row 28 comprises five burnish pads. The last row 28 of burnish pads 30 is disposed adjacent the trailing edge 18.

Each of the air bearing pads 22 is typically larger than each of the burnish pads 30. In the preferred embodiment, the air bearing pads 22 each have a major axis 22a of 0.64 mm and a minor axis 22b of 0.22 mm, while the burnish pads 30 each have a major axis 30a of 0.34 mm and a minor axis 30b of 0.20 mm. The air bearing pads 22 generate lift on the slider 12 when, during burnishing, the burnish head is brought into its operating position at a predetermined burnish head flying height above the disc surface and the disc is spun. The generated lift tilts the slider 12 so that the trailing edge 18 is positioned nearer to the disc than the leading edge 16. In this way, at least some of the burnish pads 30 come into contact with asperities or unwanted particles on the disc surface.

Burnish pads 32, 34 on the last row 28 of burnish pads 30 and farthest away from the midline 20 are configured such that they each have a graduated surface facing the disc. The graduated surface is formed by the burnish pads 32, 34 each having a step 42, 44 on their surfaces facing the disc, as shown in Figure 1. Preferably, each of the air bearing pads 22 also has a graduated surface formed by having a step 46a, 46b, 46c on its surface facing the disc. As can be seen in Figure 2, each step descends from a trailing portion of a pad to a leading portion of that pad.

In the preferred embodiment, the slider 12, including the air bearing surface 14, is made of TiC- Al_2O_3 . The air bearing surface 14 having a plurality of pads is created mainly by two ion-milling

processes. In the first ion-milling process, areas designated as pads on the air bearing surface 14 are masked. It should be noted that areas designated as steps on the pads are specifically left unmasked. Ion-milling is then performed, etching away about 300 nanometers from the unmasked areas. The first ion-milling process thus creates the steps 42, 44, 46a, 46b, 46c. In the second ion-milling process, areas designated as pads on the air bearing surface 14 are masked, including the areas designated as steps. Ion-milling is then performed, etching away the unmasked areas to a depth of about 5 μm from the original air bearing surface 14. The second ion-milling process thus creates the plurality of pads having a height of 5 μm on the etched air bearing surface 14, with the pads 22, 32, 34 bearing the steps 42, 44, 46a, 46b, 46c created by the first ion-milling process.

In the preferred embodiment as shown in Figures 1 and 2, all the graduated surfaces comprise steps 42, 44, 46a, 46b, 46c that have a curved edge that is laterally symmetrical about the major axes 22a, 30a of the pads 22, 30. Each step is typically several hundreds of nanometers in height, ranging from 100 nanometers to 500 nanometers. Appropriate graduation in pad height for maximising stability depends on head linear velocity during burnishing as well as other factors such as gram load on a suspension supporting the burnish head and pad sizes affecting air flow.

Different step heights result in different air pressures on their respective pads, resulting in different air bearing forces acting on the burnish head in opposition to the gram load borne by the suspension. The balance of gram load and air bearing forces ultimately determines flying height of the burnish head. To arrive at an appropriate step height, the desired flying height should first be specified, so that the desired air bearing forces needed to balance the gram load, which is a known quantity, can then be determined. Once the desired air bearing forces are determined, the step height needed to achieve the necessary air pressure to produce the desired air bearing forces can then be worked out.

As can be seen in Figure 2, each of the plurality of pads has a fillet 50 that joins the pad to the air bearing surface 14. The fillet 50 helps to smoothen air flow around the plurality of pads during the burnishing process, as shown in Figure 3. This is to minimise any accumulation of debris around the plurality of pads and on the air bearing surface 14. In addition, the air bearing surface 14 and the plurality of pads are coated with diamond-like carbon to improve their wear performance and thus increase operational life of the burnish head.

With reference to Figure 4, during burnishing, among the plurality of pads, air pressure is significantly much greater over pads that have a graduated surface, i.e., the three air bearing pads

22 and the burnish pads 32, 34 that are adjacent the trailing edge 18 and farthest from the midline 20 of the slider 12. Greater air pressure at the leading edge 16 helps to stabilise pitch and roll of the slider 12, while greater air pressure at the portions of the trailing edge 18 farthest from the midline 20 of the slider 12 increases air bearing stiffness to stabilize the flying height and the roll.

5 In this way, extraneous head movement is minimised and flying height can thus be better controlled. Lateral symmetry of the plurality of pads about the midline 20 of the slider 12 provides symmetrical air pressure distribution on the slider 12, as shown in Figure 4, which is indicative of minimizing roll.

10 In another embodiment, as shown in Figure 5, burnish pads 62, 64 adjacent the trailing edge 18 and farthest from the midline 20 of the slider 12 have graduated surfaces that are formed by steps 72, 74. In this embodiment, each of the steps 72, 74 has a straight edge at an oblique angle to the trailing edge.

15 Another aspect of the invention is an apparatus for levelling surface irregularities on a disc. The apparatus comprises a head assembly supported by a suspension. The suspension holds the head assembly at a predetermined distance over a disc surface. The suspension is attached to actuator head mounting arms that can move the suspension and the head assembly in a radial direction with respect to the disc surface. A burnish head as described in the embodiments above with reference
20 to Figures 1 to 5 is mounted on the head assembly.

The foregoing describes preferred embodiments of the present invention. However, it is understood by those skilled in the art that many variations or modifications in details of design or construction may be made without departing from the present invention. For example, the
25 graduated surface can be formed by other embodiments such as slopes, curved gradients, or other suitable formations instead of steps. For graduated surfaces formed by steps, such steps may have edges with different shapes instead of simple curves or oblique straight edges. The number of pads altogether, whether they be air bearing pads or burnish pads, the individual pad sizes, and the distribution pattern of the pads, may all be varied. The number and location of pads having
30 graduated surfaces may also be varied. The shapes of the pads may be other shapes such as circles or teardrops or a combination of different shapes that are suitable for allowing smooth air flow around the pads.

Claims

1. A burnish head for burnishing a disc, the burnish head comprising:
a slider having an air bearing surface, a leading edge and a trailing edge; and
5 a plurality of pads disposed on the air bearing surface, at least one of the plurality of pads having a graduated surface.
2. The burnish head of claim 1, wherein the graduated surface is formed by a step.
- 10 3. The burnish head of claim 2, wherein the at least one of the plurality of pads comprises a leading portion and a trailing portion, and further wherein the step descends from the trailing portion to the leading portion.
4. The burnish head of claim 2, wherein the step has a height ranging from 100 nanometers to
15 500 nanometers.
5. The burnish head of claim 2, wherein the step has a straight edge at an oblique angle to the trailing edge.
- 20 6. The burnish head of claim 1, wherein the at least one of the plurality of pads is an air bearing pad disposed adjacent the leading edge of the slider.
7. The burnish head of claim 1, wherein each of the at least one of the plurality of pads is a
25 burnish pad.
8. The burnish head of claim 7, wherein the burnish pad is disposed adjacent the trailing edge of the slider.
9. The burnish head of claim 8, wherein the burnish pad is disposed farthest away from a midline
30 of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.
10. The burnish head of claim 1, wherein the plurality of pads comprises a row of air bearing pads disposed adjacent the leading edge of the slider.

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11. The burnish head of claim 8, wherein the plurality of pads further comprises staggered rows of burnish pads disposed adjacent the trailing edge of the slider.
- 5 12. The burnish head of claim 10, wherein each of the air bearing pads is larger in size than each of the burnish pads.
- 10 13. The burnish head of claim 1, wherein the plurality of pads is disposed in an array laterally symmetrical about a midline of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.
14. The burnish head of claim 1, wherein each of the plurality of pads is substantially elliptical in shape.
- 15 15. The burnish head of claim 1, wherein the plurality of pads is coated with a diamond-like carbon coating.
16. An apparatus for levelling surface irregularities on a disc, the apparatus comprising:
a head assembly supported by a suspension; the suspension being attached to actuator head mounting arms; and
20 a burnish head mounted on the head assembly, the burnish head comprising:
a slider having an air bearing surface, a leading edge and a trailing edge; and
a plurality of pads disposed on the air bearing surface, at least one of the plurality of pads having a graduated surface.
- 25 17. The apparatus of claim 16, wherein the graduated surface is formed by a step.
18. The burnish head of claim 17, wherein the at least one of the plurality of pads comprises a leading portion and a trailing portion, and further wherein the step descends from the trailing portion to the leading portion.
- 30 19. The apparatus of claim 17, wherein the step has a height ranging from 100 nanometers to 500 nanometers.
20. The apparatus of claim 16, wherein the at least one of the plurality of pads is an air bearing
35 pad disposed adjacent the leading edge of the slider.

21. The apparatus of claim 16, wherein the at least one of the plurality of pads is a burnish pad.
- 5 22. The apparatus of claim 21, wherein the burnish pad is disposed adjacent the trailing edge of the slider.
23. The apparatus of claim 22, wherein the burnish pad is disposed farthest away from a midline of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.
- 10 24. The apparatus of claim 16, wherein the plurality of pads comprises a row of air bearing pads disposed adjacent the leading edge of the slider.
- 15 25. The apparatus of claim 22, wherein the plurality of pads further comprises staggered rows of burnish pads disposed adjacent the trailing edge of the slider.
26. The apparatus of claim 23, wherein each of the air bearing pads is larger in size than each of the burnish pads.
- 20 27. The apparatus of claim 16, wherein the plurality of pads is disposed in an array laterally symmetrical about a midline of the slider, the midline being parallel to direction of motion of the burnish head relative to the disc.
- 25 28. The apparatus of claim 16, wherein each of the plurality of pads is substantially elliptical in shape.
29. The apparatus of claim 16, wherein the plurality of pads is coated with a diamond-like carbon coating.